

FINAL REPORT

FLUORIDE EMISSION CONTROL SYSTEMS AND THE ENERGY
EFFICIENCY OF TUNNEL KILNS - VOLUME I, A CRITICAL
REVIEW AND PROPOSED RESEARCH PROGRAM

by

The Clay Brick Association of Canada

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FINAL REPORT

FLUORIDE - EMISSION CONTROL SYSTEMS AND
THE ENERGY EFFICIENCY OF TUNNEL KILNS:
VOLUME I - A CRITICAL REVIEW AND
PROPOSED RESEARCH PROGRAM

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EXECUTIVE SUMMARY

It has been established that the emission of fluoride containing compounds as gaseous or particulate matter from industrial sources has the potential to present some hazard to the environment in terms of:

- contributing to general acidic precipitation;
- damaging vegetation;
- injuring the health of foraging animals and, in extreme circumstances, the health of humans.

Although it is not a major source of industrial pollution, clay brick manufacturing has been identified as a significant source of gaseous fluoride emissions. Consequently, as regulatory bodies seek to control industrial emissions, it is evident that some Canadian manufacturers of heavy clay products will be required to take action to reduce the evolution of fluoride compounds from their plants. The brick industry is fully aware and concerned with this problem.

Energy consumption is a major cost factor in brick manufacturing, the major contribution to energy demand being the combustion of fossil fuel to fire kilns. Since 1972, the Canadian clay brick industry has improved its energy efficiency by approximately 29%. Because of the 'delicate' balance and control which has been developed, and is now required to ensure the energy efficient operation of dynamic systems such as tunnel kilns, it is anticipated that the incorporation of emission control measures could result in a serious reduction of the kiln energy efficiencies achieved in recent years. A major loss in energy efficiency would seriously hamper the industry's ability to compete with other construction materials in the marketplace. It is essential, therefore, that any measures employed to reduce or control atmospheric emissions are selected on the basis of their possible impact on energy efficiency in addition to their efficacy and reliability as antipollution devices.

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The purpose of this review has been to consider the major factors involved in relation to the evolution of fluoride compounds from heavy clay products during firing, the nature of current and proposed regulations governing discharge of these emissions in Canada, the technology of control, and the likely impacts such controls might have on the energy efficiency of tunnel kilns.

In preparing this review, the technical and scientific literature on brick tunnel kiln efficiency, fluoride control technology and research on the thermo-chemistry of fluoride evolution was extensively examined. Because much of the information relevant to the topic is not generally available through published literature, visits were made to research establishments, technical institutes and engineering companies in Europe and the U.S.A. known to be active in the field. These visits were made by an industry technical task force comprising of Mr. J.F. Nicks of Domtar Inc., Mr. J.P. Storer-Folt of Canada Brick Co. Ltd. and Mr. H. Penn of Brampton Brick Ltd.

Although the evolution of fluorides is complex and is not completely understood, it is clear that a number of fundamental chemical and processing factors are influential in determining the rates at which fluorides enter the kiln atmosphere (and hence ultimately their discharge with the stack gases).

The control of fluorine compound emission from a kiln can be approached in one or more of three ways:

- selection of raw materials of reduced fluoride emission potential (including additives for suppression of fluoride evolution);
- alteration of the firing procedure to reduce the rate of fluoride evolution;
- control of gaseous emissions at the stack by means of scrubbers.

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After visiting foreign plants, the technical task force expressed the following opinions:

- the employment of flue gas cleaning systems should be regarded as the last step in emission control and every plant should be treated as a specific case dependent on all the technical factors;
- the most productive approach to reduce fluoride emissions is to take a preventative approach through raw material alteration and modifications to processing procedures.

From an assessment of the published literature and the findings of the technical task force, the following conclusions were drawn:

- selection of alternate low fluoride raw materials is largely impractical in Canada for reasons of geographical location of existing plants and the limited availability of alternative sources. The use of additives and fluxes in raw material blends may, however, prove to be practical;
- because of operational and corrosion problems, the existing exhaust gas emission control technology may prove unreliable for use by the Canadian industry and could incur a significant energy penalty;
- the most practical approach to control of fluoride emissions would appear to involve changes in the firing process to reduce fluoride evolution at its source.

Although it is clear on an a priori basis that the use of additives and fluxes, changes in thermal profiles or kiln atmosphere conditions or the introduction of scrubbers on kiln exhaust systems, must have impact upon the energy efficiency of the production process, no significant information was found from literature sources or from the industry visits to Europe or U.S.A. It is the opinion of the authors that a program of research is required to develop and evaluate the more promising options for fluoride control with particular reference to understanding the nature and magnitude of their impact on energy efficiency. The objective of this program should be the development of technical guidelines for use by the brick industry to assist in the control of fluoride emissions by practically applicable methods having minimal negative energy impact on the firing processes.

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It is considered that the necessary data can be obtained through a research program comprising the following six project elements:

1. Experimental examination under process conditions of the fluoride emission profiles and energy balances at brick manufacturing plants in Canada.
2. Experimental examination under controlled laboratory conditions of the effects of thermal treatment and kiln atmosphere changes on the emission of fluorides from selected Canadian brickmaking materials.
3. Experimental investigation of the effects of selected additives and fluxes on the emission of fluorides from selected Canadian brickmaking materials.
4. Experimental evaluation of the effects of process changes (designed to incorporate the findings of research implemented under 2 and 3) on fluoride emission profiles and energy balances at selected brick manufacturing plants in Canada.
5. Evaluation of new fluoride emission control technology currently under development outside of Canada.
6. Preparation of a summary review of the findings from elements 1 to 5 and development of technological guidelines for the selection of energy-efficient methods of reducing fluoride emissions from brickmaking kilns.

It is expected that this program could be completed over a three-year period at a total cost of approximately \$502,000.

Details of recommended project elements for such a program are presented in the form of "Work Statements" in Section 2 of this report.

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SECTION I

A Review of Fluoride Emissions and the
Potential Impact of their Control Upon
Energy Efficiency of Tunnel Kilns Used
in the Clay Brick Industry

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EXHIBIT 1.1

LISTING OF THE CANADIAN CLAY BRICK MANUFACTURERS,
THEIR PLANTS & LOCATIONS

COMPANY	Total No. Of Plants	LOCATION		
		No.	Town/City	Province
Brampton Brick Ltd.	1	1	Brampton	Ontario
Brique Citadelle Ltée	1	1	Quebec City	Quebec
Brique Scott Ltée	1	1	Scott Junction	Quebec
Canada Brick Co. Ltd.	4	1	Burlington	Ontario
		2	Streetsville	Ontario
		1	La Prairie	Quebec
Domtar Construction Materials	3	1	Mississauga	Ontario
		1	Ottawa	Ontario
		1	La Prairie	Quebec
Estevan Brick Co. Ltd.	1	1	Estevan	Saskatchewan
Hamilton Brick Ltd.	1	1	Hamilton	Ontario
I-X-L Industries Ltd.	5	1	Lockport	Manitoba
		1	Edmonton	Alberta
		2	Medicine Hat	Alberta
		1	Regina	Saskatchewan
Queabrique Inc.	1	1	East Angus	Quebec
L.E. Shaw Ltd.	2	1	Lantz	Nova Scotia
		1	Chipman	New Brunswick
Thunderbrick Ltd.	1	1	Thunder Bay	Ontario
Toronto Brick Co.	1	1	Toronto	Ontario
Trinity Brick Products Ltd.	1	1	Trinity Bay	Newfoundland

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1. INTRODUCTION

1.1 The Canadian Clay Brick Industry

The Canadian Clay Brick industry consists of 13 companies operating 23 manufacturing plants across the country from Newfoundland to Alberta. Exhibit 1.1 shows a listing of these companies together with the number and location of manufacturing plants operating.

It can be seen from Exhibit 1.1 that the Canada Brick Company Ltd., Domet Construction Materials, I-XL Industries Limited and L.E. Shaw Limited operate more than one facility. These four companies together with Brampton Brick Limited and the Toronto Brick Company are members of the Clay Brick Association of Canada.

Since 1975, the Canadian Clay Brick industry has manufactured and/or sold in excess of 550 million brick equivalents per year.¹ Over the last four years, the average figure has been 650 million brick equivalents per year including a high of 690 million units in 1979.

1.2 The Clay Brick Manufacturing Process

The manufacturing process for structural clay products typically comprises the following major activities:

- (a) Excavation of raw material - local clays and shales.
- (b) Crushing and grinding to the desired particle size distribution.
- (c) Addition of modifying ingredients - e.g. pigments, barium carbonate for scum control, plasticizers and/or binders.
- (d) Conditioning/tempering with water to produce a suitably plastic mass.

[illegible]

- (e) Forming - by high pressure continuous extrusion through dies of the desired cross-section, followed by cutting to the required size.
- (f) Loading onto kiln cars.
- (g) Drying (in tunnel dryers).
- (h) Firing (in continuous tunnel kilns).
- (i) Unloading, grading, packaging and shipment.

Typically, commercially viable clay brick plants will manufacture in excess of 25 million bricks per year (and up to 100 million). Thus, in order to maintain efficiency, they require a high degree of heavy engineering and automation. However, manual and semi-automatic forming systems are still used to produce aesthetic effects for special products.

Energy consumption is a major cost factor in brick manufacturing, the major contribution to energy demand being the combustion of fossil fuel to fire kilns.

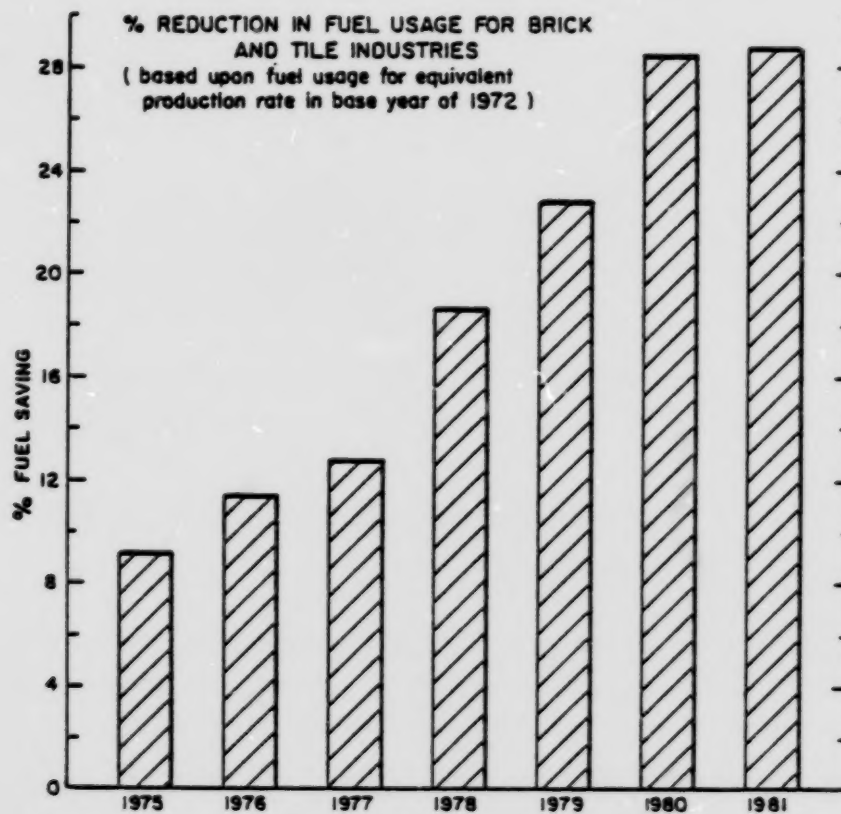
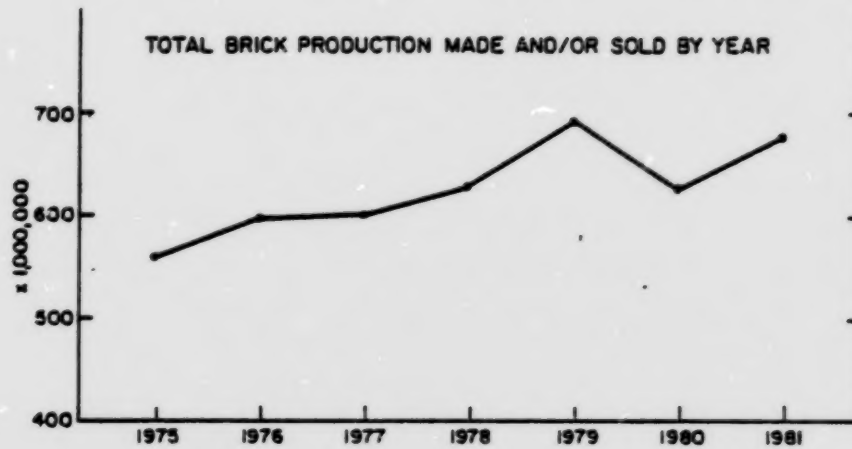
On average, the brick making process requires an energy consumption of approximately 5.48 GJ per thousand brick equivalents.

1.2.1 History of Energy Conservation in the Canadian Clay Brick Industry

Prior to 1970, the relatively low cost of fuel fostered an attitude within the heavy-clay products industry whereby the kiln (or firing process) was used to "fine-tune" the quality of the finished product. Firing practices were not necessarily optimized for thermal or fuel efficiency but rather were centered upon producing a preferred or satisfactory product.

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EXHIBIT 1.2



The massive escalation in the cost of energy experienced by Canadian industry in the mid to late seventies caused clay brick manufacturers to find means of conserving energy and improving efficiencies in order to permit brick to remain cost competitive with other structural materials.

In 1975, the Clay Brick Association of Canada undertook the task of collecting energy consumption data from Canadian brick and tile manufacturers and reporting it to the Federal Government Task Force on Energy Conservation in the Industrial Minerals Sector. These data have been reported annually and provide a record of the advances made by the industry in recent years. Using 1972 energy consumption data as a base, the Canadian clay brick and tile sub-sector showed a decrease of 28.78% in energy consumption per manufactured unit in 1981 compared with the base year. Exhibit 1.2 shows the progress of the industry's energy conservation effort since 1975.

1.2.2 Environmental Impact of Clay Brick Production

Although it is not a major source of industrial pollution, clay brick manufacturing has been identified as a significant source of gaseous fluorides. The fluorides, which exist in small and varying quantities in the raw materials, are evolved during the firing process and pass into the atmosphere through the exhaust stack. At the present time, the Canadian industry possesses no technology or capability to control such emissions.

1.2.3 Impact of Environmental Control Devices on Energy Use and Conservation

Recent concern expressed by regulatory agencies over fluoride emissions, has indicated that emission control devices

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may be required for brick kilns. The brick industry is equally aware and concerned with the problem, however, due to the 'delicate' balance and control which has been developed, and is now required to ensure the energy efficient operation of dynamic systems such as tunnel kilns, it is anticipated that the incorporation of emission control measures could result in a serious reduction of the kiln energy efficiencies achieved in recent years. A major loss in energy efficiency would seriously hamper the industry's ability to compete with other construction materials in the marketplace. It is essential, therefore, that any measures employed to reduce or control atmospheric emissions are selected on the basis of their possible impact on energy efficiency in addition to their efficacy and reliability as anti-pollution devices.

2. INDUSTRIAL FLUORIDE EMISSIONS AND THEIR EFFECTS

2.1 Sources of Fluoride Emission

In recent years,^{2,3} there has been an increase in the distribution of fluoride in the environment, the principal sources being:

- increasing industrial activity;
- the introduction of fluoridated municipal water supplies;
- the increased use of aerosols, pharmaceuticals and toiletries containing fluorine compounds;
- the use of high-octane gasolines manufactured by HF catalysis;
- the distribution of foods grown in high fluoride-content soils.

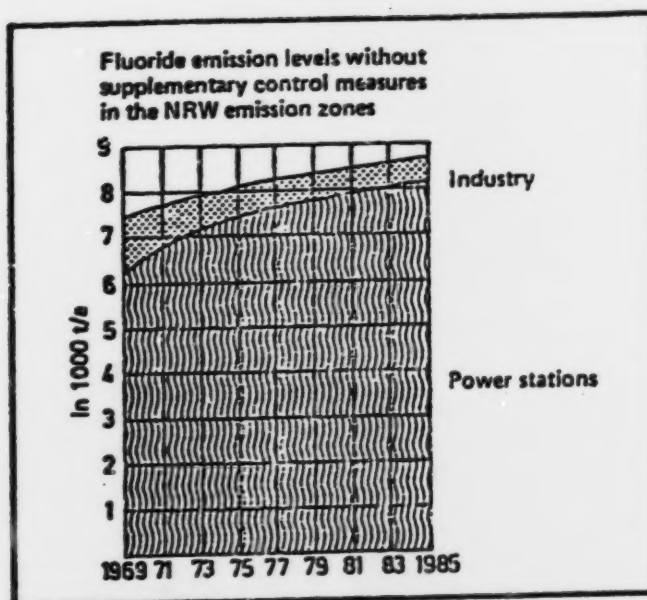
In 1968 and again in 1969, Carpenter^{2,3} indicated that most of the fluoride found in rain and snow samples could not be explained as originating from industrial activity, volcanic eruptions or soil dust; the major portion (80 - 90%) apparently originates from the ocean as "cyclic salt" by "injection" or evaporation into the atmosphere. He further indicated that although local concentrations due to industrial activity may be a source for concern, industrial emissions are inadequate to account for the broad base atmospheric fluoride concentrations.

The ceramic manufacturing industries in general, including the clay brick industry, have long been recognized as sources of gaseous fluoride emissions; the fluorine being evolved during the firing process. The problem and its effect on vegetation was reported as early as 1913.⁴

While fluoride concentrations in clays and shales are relatively small (i.e. generally in ppm concentrations), the large volume of production in the brick industry causes it to be a major source of fluoride emissions. In 1971 it was stated⁵ at an International

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EXHIBIT 2.1



Environmental Control Seminar in Rotterdam, that the brick and tile industry was, at that time, the single largest source of fluoride emissions in the U.S.A.

Other major industrial sources of fluoride emissions are the aluminum, steel and phosphate fertilizer manufacturing industries. The environmental problems of these industries have long been recognized and consequently they have been studied quite intensely.^{6,7,8} Another major source of fluoride emission which is frequently not considered is the combustion of coal, particularly by thermal power plants.^{4,9} Coal contains from 40 to 300 ppm of fluoride,⁹ depending upon its source. Recent studies have shown that in Germany, (which relies heavily on coal-fired electrical generating stations) the total emissions from other industrial plants are relatively slight^{10,11} when compared to emissions from power stations. This is shown in chart form in Exhibit 2.1. The author¹¹ suggests that the tall stacks found in power plants effectively prevent local damage to plant and animal life (and, therefore, they frequently escape public notice) because of high dilution in the upper air layers of the atmosphere.

2.2 Effects of Fluoride in the Environment

2.2.1 Effects on Vegetation and Animal Health

The toxicity of gaseous and particulate fluorides to both plant and animal life has been well documented and reviewed in recent years,^{12,13} and monographs concerned with the problem have been prepared.¹⁴ While differing varieties of plant life are not equally affected by fluoride, some being more resistant than others, young plants appear to be more sensitive than mature growths and environmental guidelines recognize that the plants are more susceptible to fluoride-induced damage during the growing season.⁵

Fluoride-induced damage to animal and plant life was attributed to ceramic factories in England in 1948, where fluorosis in cattle resulted from contamination of pastures up to a mile from a brick plant.¹⁵ Similar incidences of fluoride contamination of grazing lands adjacent to brick plants have recently been recorded^{16,17,18} in Australia, Belgium and Italy. In the U.S.A., brick, tile and pottery factories have been labelled as the source of fluoride damage to commercial nurseries and apricot orchards.⁴ In Canada, peach orchards located within a half mile radius of a drainage tile plant were found to have suffered slight, but significant, damage from fluoride emissions which could be attributed to the factory.¹⁹ In Germany, fluoride damage in vineyards due to emissions from a local brick plant have been reported²⁰ while in Japan several studies^{21,22,23} on the effect of fluoride emissions from tile factories on neighbouring plant life have been conducted. Recently, detailed investigations into the effects of industrial fluoride emissions on various kinds of vegetation have been completed in Canada,²⁴ Holland,²⁵ Germany²⁶ and England.²⁷

2.2.2 Effects on Human Health

One of the earliest recorded instances of widespread fluoride damage to human health occurred in the Meeuse Valley in Belgium in 1930.⁴ In that incident, sixty deaths were attributed to what was described as "fluorine intoxication", brought about by a combination of industrial air pollution and meteorological factors. It was considered that a portion of the air pollution was attributable to four glass plants and ceramic factories in the area.

Industrial fluoride emissions were held responsible for a similar disaster that occurred in Donora, Pennsylvania in 1948 where 20 people died. There were no ceramic industry plants in the area at that time.

A certain level of fluoride intake is considered desirable to human health in particular with regard to the control of dental caries. The optimum level of fluoride intake for humans has been defined⁶ as that which provides the highest degree of protection with the lowest degree of mottled enamel for teeth, and this level refers to the amount added to drinking water. However, no upper (or safe limit) has ever been determined, since dietary habits would influence this value profoundly.

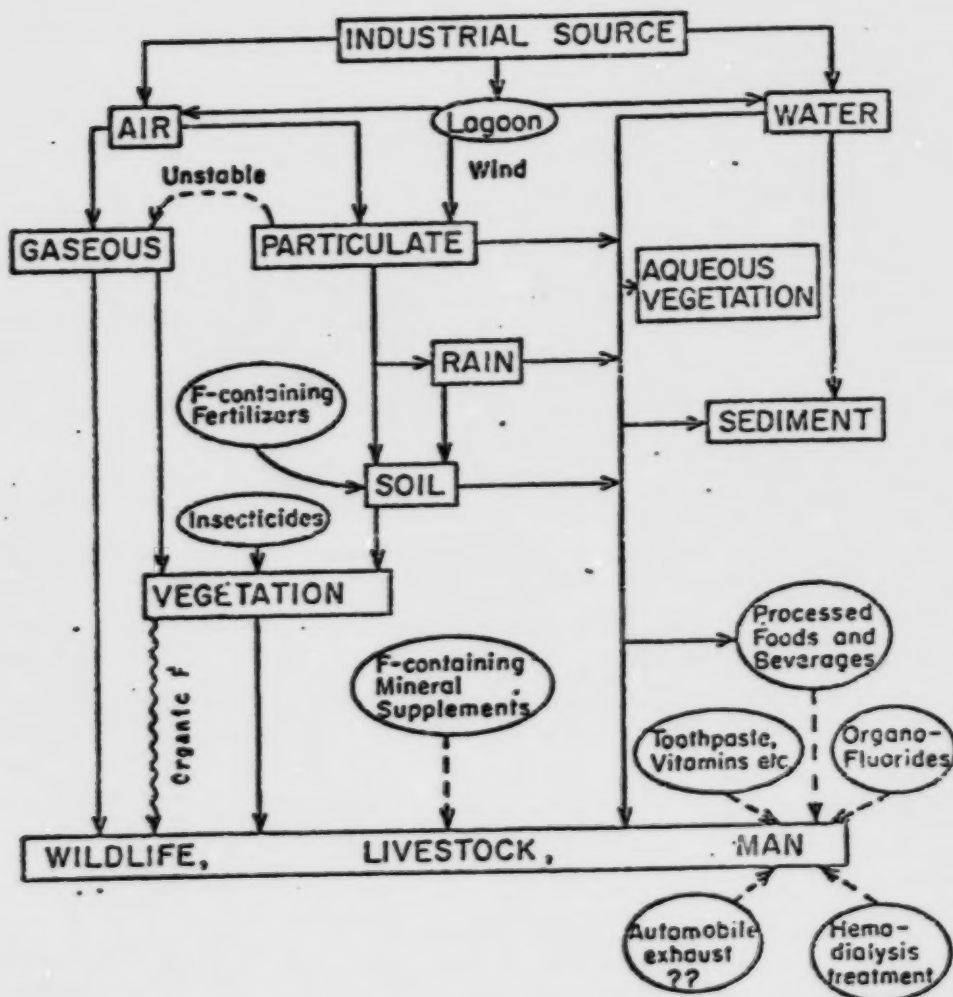
Sprecht and Calaceto⁶ have summarized the likely effects of exposure as follows:

"Acute damage to the skin from human exposure to fluorides results from the contact of fluoride acids, while acute effects of respiratory exposure are commonly associated with exposure to air-borne fluorides in the gaseous state. Observed effects of the inhalation of hydrogen fluoride in air have been found to be:

- "1. At concentrations of 3 ppm or less - no local and immediate systemic effects are noticed.
- "2. At 10 ppm - many exposed persons make complaints of discomfort.
- "3. At 30 ppm - all exposed persons complain and object seriously to remaining in the environment.
- "4. Animals (rabbits) have been exposed to a concentration of 37 ppm for six days without evident harmful effects.
- "5. Human experimental subjects exposed briefly to air containing 60 ppm experienced definite irritation of conjunctiva and nasal passages and tickling and discomfort of the pharynx and trachea.
- "6. The highest concentration tolerable for longer than one minute by two men who experienced smarting of the skin as well as the symptoms given above was 120 ppm.
- "7. Concentrations on the order of 500 or 1,000 ppm or more in the air breathed by man induce the following responses: extreme burning pain in eyes, nose, mouth, pharynx, and upper chest; water discharged from nose and eyes; tingling and burning of skin, gasping and coughing; laryngospasm."

EXHIBIT 2.2

THE MAN-MADE FLUORIDE CHAIN



Derryberry et al²⁸ made an extensive study of a large group of workers at a phosphate fertilizer plant exposed to relatively large and continuous levels of fluoride for up to 25 years. Any instances of ill health could not be attributed directly to fluorides because of the influence of many other factors.

In a study carried out by the Florida State Board of Health²⁹ on a group of school children residing near a group of fertilizer plants, no evidence of fluorosis was found in their teeth and investigations were discontinued. Similarly, the health of children living in the vicinity of an alumina plant was compared³⁰ with those living in a control district, however, no perceptible difference in general health, as indicated by subjective complaints, were observed.

Following a survey on areas of Stoke-on-Trent where there are high local concentrations of fluoride from ceramic plants, Bennett and Barratt²⁷ quoted their own data and that of others^{31, 32, 33} and concluded that maximum daily fluoride intakes by residents and workers (0.06 mg F/day) were small compared to normal dietary intakes^{34, 35} (up to 1.8 mg F/day) particularly where there is a high tea consumption among the population. Reports from Texas³³ suggest that maximum daily intakes in the range 5 - 8 mg F/day will not cause detectable osteosclerotic changes.

A recent dental survey³⁶ conducted for the Ontario Ministry of Health on populations neighbouring brick plants in Toronto and Brampton, Ontario, indicated that there was no evidence of the occurrence of dental fluorosis which might be attributed to local fluoride emissions.

The sequence of the man made fluoride chain, the various inputs and their relationship to each other, to vegetation, to animal and human life are shown in Exhibit 2.2.¹⁴

2.2.3 Property Damage

In addition to biological effects, there have also been some reports of property damage attributable to fluoride emissions from ceramic plants. Etching of enamel surfaces³⁷ on finished products and of glass windows in adjoining buildings^{16,38} being typical examples.

3. FLUORIDE EMISSION STANDARDS AND MEASUREMENT

3.1 International Experience

There are no universally accepted standards for fluoride emissions or hazardous concentrations; however, as the international technical literature indicates, concern over the issue is worldwide.^{39,40} Most countries employ their own standards and bases for their determination. It would appear that the standards are determined from literature on fluorosis and computed safety factors, and are to some extent also influenced by the methods and accuracy of monitoring equipment and experimental procedures. Many of the standards are multi-tiered, to accommodate variations in geography, topography and the growing cycles of vegetation.

Of all of the countries where concern over fluoride emissions have been expressed, Germany appears to have conducted the most work both from an environmental and industrial point of view. In Canada, the Province of Ontario has set standards and guidelines and presently leads the other provinces in this respect.

Much has been written in recent years regarding attempts by the German brick industry to eliminate fluoride emissions, thus, it is valuable to consider the basis of the German standards for comparison with current and possible future legislation in Canada.

3.1.1 German Regulations

The German Clean Air Guide (T.A. Luft) specifies that a permissible emission limit for brick kilns is $30 \text{ mg F}^-/\text{m}^3$ of waste gas. It also says that if the pollution hazard is particularly high (e.g. if the kiln installation is located in

front of, or on, a sloping site), the gaseous emission of inorganic fluoride compounds in the waste gas should not exceed 5 mg/F⁻/m³. Both limiting values are based on a CO₂ content by volume of 3%. (Measured values taken with CO₂ concentrations in the waste gas which differ from the above have to be converted in order to compare them with the prescribed value at 3%). The 3% CO₂ figure was introduced to prevent operators diluting flue gas by infiltration of outside air. The German Clean Air Guide also stipulates that dust emissions through kiln chimneys should not exceed 150 g/m³ of waste gas, and includes a mathematical procedure for determining minimum stack heights to ensure dispersion of emissions.

3.2 Canadian Regulations

Canadian regulations are not as well developed as those of Germany. In Canada, air pollution control is a shared federal-provincial jurisdiction. The National Air Pollution Control Program is therefore developed with a great deal of emphasis on consultation and cooperation with provincial environment agencies. Control programs initiated by the federal Environmental Protection Service are intended to be implemented by provincial agencies whenever possible.

National Air Quality Objectives have been developed⁴¹ and are designed to protect public health and the environment by setting limits on the concentrations of contaminants in the ambient air. The Clean Air Act makes provision for three levels of air quality objectives: desirable, acceptable, and tolerable, for major contaminants.

The maximum desirable level defines the ultimate goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology.

The maximum acceptable level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.

The proposed National Air Quality Objectives as they apply to hydrogen fluoride are shown below:

Air Contaminant	Maximum Desirable Level	Maximum Acceptable Level
Hydrogen Fluoride		
Average concentration over a 70-day period		0.20 $\mu\text{g}/\text{m}^3$ (0.2 ppb)
Average concentration over a 30-day period		0.35 $\mu\text{g}/\text{m}^3$ (0.4 ppb)
Average concentration over a 7-day period	0.20 $\mu\text{g}/\text{m}^3$ (0.2 ppb)	0.55 $\mu\text{g}/\text{m}^3$ (0.7 ppb)
Average concentration over a 24-hour period	0.40 $\mu\text{g}/\text{m}^3$ (0.5 ppb)	0.85 $\mu\text{g}/\text{m}^3$ (1.0 ppb)

Not all of the provinces make specific reference⁴² to fluoride in their respective environmental, or "clean air" legislation. Ontario has the most complete guidelines of all of the provinces. A summary of relevant provincial guidelines is given below, with particular attention being given to the comprehensive guidelines set forth by Ontario.

3.2.1 Ontario

The Government of Ontario Regulations 873/74 issued under the Environmental Protection Act, 1971, as amended, states that:

"No person shall cause or permit to be caused the emission of any air contaminant to such extent or degree as may;

- "(a) cause discomfort to persons
- "(b) cause loss of enjoyment of normal use of property
- "(c) interfere with normal conduct of business, or
- "(d) cause damage to property."

The regulation goes on to state that the maximum concentration of fluoride contaminant at a point of impingement from the source of the contaminant shall not be greater than the following:

<u>Gaseous Fluorides</u>	(April 15th to October 15th) "growing season" - <u>4.3 $\mu\text{g HF/m}^3$ of air</u>
<u>Total Fluorides</u>	(April 15th to October 15th) "growing season" - <u>8.6 $\mu\text{g HF/m}^3$ of air</u>
<u>Total Fluorides</u>	(October 16th to April 14th) "dormant season" - <u>17.2 $\mu\text{g HF/m}^3$ of air</u>

The standard acceptable level of fluoride allowed in the air as determined by the lime candle technique to ensure no injury to vegetation has been set at 40 micrograms per 100 sq. cm of filter per 30 days of exposure during the growing season and 80 micrograms per 100 sq. cm of filter per 30 days of exposure during the rest of the year. Unfortunately, there are major deficiencies^{43,44} with the lime-candle technique and error rates of up to 50% have been reported.

The presence of particulate fluorides while not considered a serious human hazard will, of course, increase the total fluoride content of a foraging animal's diet and can, therefore, pose a potential hazard for grazing cattle. Accordingly, the Ministry has set a criterion of 35 ppm concentration of fluoride in unwashed foliage as a protection level to prevent fluorosis in cattle.

The Ontario Ministry of the Environment actively monitors fluoride emissions in many ways; any one of which may be the ultimate cause of a request to reduce emissions.

When such monitoring indicates increased fluoride levels, the Ministry conducts visual observations and sample analysis of the vegetation. In cases where property owners lodge damage complaints, the Ministry compiles a report which is submitted to both the owners and the apparent offending Company involved in the hope that they will come to a settlement. When fluoride levels in air and vegetation indicate a problem, the Ministry requires the Company to reduce the level of emissions.

In regions where fluoride pollution is suspected or reported, the direct measurement of the fluoride content of vegetation is also conducted. Standard levels of acceptable fluoride concentrations in vegetation (leaves) are set at 20 mg/kg for washed foliage and 35 mg/kg for unwashed foliage (as stated above).

Ultimately, of course, the direct measurement of stack emissions and the calculation of fallout (or concentration at point of impingement) outside property boundaries, provides firm evidence of the degree of fluoride contamination from any given source. The Ontario standards for such concentrations at the point of impingement have been previously listed. The actual stack emission values are, therefore, the most important of all of the 'fluoride concentrations' which can be measured, in that they relate directly to the given source.

3.2.2 Alberta

The Alberta Clean Air Act contains plant emission guidelines for various industries, however, there appear to be none which

might include the clay brick industry. Industries which are included in the fluoride level legislation are phosphoric acid manufacture, ammonium phosphate manufacture and phosphate rock grinding. Allowable emission levels are related to the average daily production rate of individual plants and regulations are stricter for new plants than for old ones.

Some specific regulations are as follows:

- (i) for phosphate rock grinding and ammonium phosphate manufacture:
 - 0.03 lb/HF/ton of product, average daily rate for new plants;
 - 0.05 lb/HF/ton of product, average daily rate for old plants.
- (ii) for phosphoric acid plants:
 - 0.025 lbs/HF/ton of P_2O_5 produced, daily average for any plant.

In addition, for both of the above, maximum cumulative ground level concentration calculated from emissions must not exceed 5 ppbv. HF and concentration in local forage must not exceed 35 ppm (dry weight).

3.2.3 British Columbia

British Columbia has "Pollution Control Objectives" for various industries, however, the clay brick industry is not specifically identified. Processes which are included in the legislation are ammonium phosphate production, aluminum reduction and lead smelting. If it is included anywhere in the regulations, it is possible that clay brick manufacturing would come under the mining, smelting and related industries categories for which

emission ranges are considered as follows:

- (i) Ambient Air Control Objectives
Fluorine (F) 0.1 - 2.0 $\mu\text{g}/\text{m}^3$
- (ii) Control Objectives as HF 1.0 - 10.0 ppm
(for gaseous and particulate emissions)

3.2.4 Manitoba

Manitoba's air quality standards quote two values in the form of maximum acceptable levels and maximum desirable levels. The maximum acceptable level is that deemed essential to provide adequate protection for soils, water, vegetation, materials, animals, visibility and personal well-being. The maximum desirable level defines the long-term goal for air quality and provides a basis for anti-degradation policy for unpolluted parts of the province and for the continuing development of control technology.

The stipulated levels are as follows:

Fluorides in Air	Max. Acceptable Level	0.85 $\mu\text{g}/\text{m}^3$
(as HF)		
(24 hour average)	Max. Desirable Level	0.4 $\mu\text{g}/\text{m}^3$

In addition to the above, maximum fluoridation rates for foliage over a 30-day period are 40 $\mu\text{g}/100 \text{ cm}^2$.

3.2.5 Newfoundland

The Province of Newfoundland quotes two sets of guidelines; The "Criteria for Acceptable Air Quality" are average concentrations used for the purpose of attaining a high quality environment

while the "Standards for Emitted Contaminants" are the standards for concentration of air contaminants from a stationary source at the point of impingement.

The values are as follows:

(i) Criteria for Acceptable Air Quality

Fluorides (as HF) - Average concentration of
0.90 $\mu\text{g}/\text{m}^3$ per 24 hours

and/or - Average concentration of
0.45 $\mu\text{g}/\text{m}^3$ per 30 days

Total Fluoride - Average concentration of
(Gaseous & 1.80 $\mu\text{g}/\text{m}^3$ per 24 hours
Particulate)

and/or - Average concentration of
0.90 $\mu\text{g}/\text{m}^3$ per 30 days

(ii) Standards for Emitted Contaminants

Gaseous Fluorides - 4.5 $\mu\text{g}/\text{m}^3$ per 30 minutes
(as HF)

Total Fluorides - 9.0 $\mu\text{g}/\text{m}^3$ per 30 minutes
(HF)

In addition to the above, maximum average fluoride levels are set for neighbouring forage which should not exceed 35 parts of fluoride per one million parts of forage (dry weight).

3.2.6 Quebec

In the Province of Quebec, it is "forbidden" to emit or discharge fluorides into the environment in such amount that they exceed the following standards in forage, for feeding animals, and samples taken outside the limits of the property where the emission source is situated.

<u>Dry Basis Weight Concentration</u>	<u>Duration of Sampling</u>
40 ppm F ⁻	Average over 12 months.
60 ppm F ⁻	Monthly average which cannot be exceeded for more than 2 conse- cutive months per year.
80 ppm F ⁻	Monthly average that cannot be exceeded more than one month per year

3.2.7 Provinces of Saskatchewan, Nova Scotia, P.E.I. and
New Brunswick

No regulations or guidelines governing fluoride
emissions have been formulated for these provinces.

4. THE ORIGINS OF FLUORIDE EMISSIONS FROM THE CLAY BRICK INDUSTRY

4.1 Fluorine Content of Ceramic Raw Materials

Fluorine chemically bound as fluoride is widely distributed in the earth's crust,¹⁷ which contains an average of 0.065% of fluoride in more than 100 different minerals. Of these, fluorspar, cryolite and fluoroapatite are some of the more common fluoride-rich minerals.

As an impurity in clays and shales, fluorides are probably more widespread than is generally recognized. Because fluoride and hydroxyl ions are of nearly equal size and both are monovalent, isomorphous substitution of one for the other can be anticipated in clay mineral structures. In addition, these raw materials also contain many other hydroxyl bearing accessory minerals such as mica, hornblende and apatite, among others, all of which are known to contain strongly-bound fluorine.⁴⁵ Coupled with the frequent presence of the mineral fluorspar (CaF_2), these sources provide a potential for fluoride emissions during the ceramic firing cycle.

Robinson and Edgington⁴⁶ analyzed some 30 samples of American (U.S.) surface clays for fluorine content and reported values of up to 7,040 ppm. Wilson and Johnson⁴⁷ analyzed four American brick clays and discovered fluoride values of up to 550 ppm.

In Ontario, it has been suggested⁴⁸ that the fluoride content of the Queenston and Dundas shales will vary in the range of 500 - 1000 ppm depending upon the location and depth of the strata of the sedimental deposit. It may be presumed that other clays and shales used by the Canadian brick industry contain similar levels and will show similar variability in fluoride content.

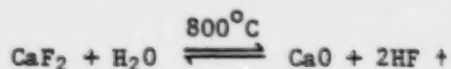
4.2 The Emission of Fluoride During the Firing Cycle

During the heating stages of the ceramic manufacturing process, the fluoride present in the raw materials is primarily involved as gaseous hydrogen fluoride (HF) or silicon tetrafluoride (SiF_4), although particulate calcium fluoride (CaF_2) and particulate ammonium fluosilicate³⁸ ($(\text{NH}_4)_2\text{SiF}_6$) may also be formed when organic impurities are present.

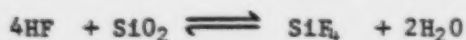
The exact temperature at which decomposition begins is unclear; it is evident, however, that the presence of steam and transition metal ions accelerate the reactions.^{49,50,51,52} Recent studies⁵³ conducted in Germany indicate that for brick clays, no fluoride is emitted at temperatures below 300°C , thus any conventional brick drying system should be free of fluoride emission. However, Troll & Farzaneh⁴⁵ have clearly demonstrated that different silicates show differing degrees of fluorine bonding in the crystal lattice, and that whereas the majority of silicates lose fluoride at approximately 800°C , some (such as apatite, phlogopite and some muscovites) begin to lose fluoride at temperatures below 400°C . Routschka & Madjic⁵⁴ on the other hand have shown that this may also be a function of the degree of fineness. In their studies, they showed that the finer the clay, the lower the temperature required to remove the fluoride and that in some cases, this could occur at temperatures as low as 450°C . They were also able to determine that the dwell time in the temperature range between 800°C and the final sintering temperature of the clay was the main controlling factor for fluoride emission. Expanding on this work, both Tünker and Schmidt⁵¹ and Kother and Pauls⁵² have monitored the rate of fluoride evolution from clays during the firing process, indicating that emission rates peak between 800°C and 1000°C and then subside as sintering of the clays is initiated.

Luxon³⁸ suggested the following reaction sequence for fluoride emission from pottery bodies containing some fluorspar:

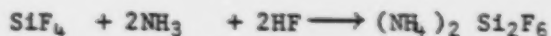
"At temperatures above 800°C, calcium fluoride reacts with water vapour to form hydrofluoric acid:



"The hydrofluoric acid so formed reacts with silica in the body of the ware to give silicon tetrafluoride.



"If there are organic impurities within the clays then the silicon tetrafluoride can then react in the vapour phase with ammonia, formed by the decomposition of the organic impurities, in the body of the ware to give silicon diaminotetrafluoride and similar compounds. These in turn react to give ammonium fluosilicate as a final product. This reaction may be summarized as follows:



"The ammonium fluosilicate will then condense into solid particles in cooler parts of the kiln and/or stack."

It is probable that at least part of this sequence of reactions takes place in brick kilns. When the shales contain organic impurities, the complete sequence may occur, in which case the resulting fluoride emissions would be a combination of both gaseous and particulate matter. Because of the operating conditions of brick kilns, any particulates emitted would be of extremely fine particle size, and consequently could be classified as fume or smoke.

4.3 Other Factors which Influence Fluoride Emissions

Early estimates⁵ of the contribution of the brick industry to the total industrial fluoride emissions were based entirely on laboratory experiments and assumed that all of the available fluoride in the clay or shale was evolved. It has been clearly demonstrated in recent years^{48 51 52} that only a portion of the available fluoride is in fact emitted during the firing operation.

The relative proportion of fluoride evolved is obviously not the same for every clay fired to the same temperature;⁴⁵ it will vary with each raw material and with differences in equipment and operational procedures from plant to plant. Fluoride emission occurs during the firing process when the fluorine compounds entrained within the body become thermodynamically unstable. While the presence of water vapour trapped within the firing atmosphere appears to be of prime importance, there are several other important controlling factors, namely:^{50, 51, 52, 54, 55}

- (a) Firing Cycle - The total firing time, the maximum firing temperature and the dwell time between 800°C and the sintering range of the clay.
- (b) Type of Kiln - Tunnel kilns can be expected to be the source of higher emissions than periodic kilns. The high rate of flow of flue gases, air and humidity over the ware at elevated temperatures increases the rate of removal of fluoride: products in the centre of the kiln charge (hack) will lose less fluoride than those on the outer edges of the kiln car due to temperature gradients and less exposure to high velocity gases.
- (c) Kiln Operating Conditions - The kiln atmosphere, air/fuel ratios, type of fuel, air leakage and the degree of gaseous recirculation will influence the rate and extent of fluoride

emissions during firing. Passage of hot gases (by recirculation) over the cooled charge may lead to re-adsorption of a portion of the evolved fluoride.

- (d) The Degree of Compaction of the Product and Particle Size of the Raw Materials - Denser compacts have been shown to evolve less fluoride than less dense or more porous products. Similarly, finely-ground raw materials yield higher fluoride levels than dense coarse-grained materials. The cross-sectional dimensions of the ware will also influence fluoride emissions.
- (e) Microstructure and Porosity of Product being Fired - Fluoride migration encounters little resistance in porous ceramic materials whereas the presence of densified phases can effectively impede diffusion.
- (f) The Initial Fluoride Content of the Raw Material - Although fluoride emission is not in general stoichiometric, it may be presumed, other conditions being equal, that raw materials high in fluoride content will cause higher levels of emission.
- (g) Calcium Carbonate Content - The presence of finely-divided, naturally occurring CaCO_3 in the raw materials has been cited as a factor in limiting the level of fluoride evaluation⁵⁶. There is disagreement in the literature on the question as to whether CaCO_3 as an additive is as effective as when it occurs naturally as inclusions in clays.⁵⁴

5. CONTROL OF FLUORIDE EMISSIONS

5.1 Possible Techniques

In principle, control of fluoride emissions can be applied at one of three stages in the brickmaking process:

- during the selection of raw material;
- during firing;
- at the gas exhaust stack.

5.2 The Control of Raw Materials

There are three general approaches to limiting fluoride emissions through the selection of raw materials:

- (a) the use of clays and shales with minimal fluoride concentrations;
- (b) the removal of fluorine bearing minerals from the clays and shales, and
- (c) the incorporation of some ingredient into the raw material mix which will suppress fluoride evolution during firing.

In principle, the most desired approach would be to select brickmaking clays and shales from sources either low in fluorine containing minerals or from sources that show low rates of fluoride evolution during firing. However, the supply of brickmaking clays and shales is limited in Canada, especially in the more densely populated areas where the demand for bricks is high. Consequently, it is largely impractical to consider specialized selection of brickmaking materials as a means to fluoride control. Additionally, in some regions, such as Ontario^{57, 58} although two different brickmaking shales are found, both types contain similar quantities of fluorine present

in similar mineral states.

On a technical basis, it is probably feasible to beneficiate clays and shales to remove fluorine contaminants using complex flotation and other mineral dressing techniques. However, such an approach would change clay mining from a simple process producing an inexpensive raw material to one which is both complex and expensive. Such technology is currently foreign to the processing of ceramic raw materials except in the case of the highest-priced (paper grade) kaolins where the cost of such processing can be justified.

It is suggested⁵⁹ that fluoride emissions can be fully or partially prevented by the addition of calcium hydroxide to the raw material and the subsequent formation of calcium fluoride in the firing load. The work of Routschka and Majdic⁵⁴, however, suggested that this approach was unpredictable and in some cases totally ineffective. In addition, the incorporation of lime into clay raw materials in this manner will have a pigment effect on the brick, driving them into the buff range. It will also have a deleterious effect on the physical properties compared to red brick for an equivalent firing schedule.

More recent experiments in German brickworks have shown that fluoride expulsion can be reduced by the addition of metal hydroxides⁶⁰. However, the effect of using waste products on brick quality should first be determined. The possibility of pollutant emission from the waste materials should also be examined, as it would serve little purpose to use an additive which reduces fluoride emission but causes, for example, emission of hydrogen chloride. The possible benefits of this approach justify the performance of some research on its application to Canadian raw materials.

5.3 Modification of the Firing Schedule

5.3.1 Reduction of the Firing Temperature

Because the evolution of fluoride from clays and shales is a temperature sensitive reaction, the rate of which increases as the operating temperature approaches the vitrification range, it has been suggested⁶¹ that if the firing temperature of brick products could be lowered significantly it would be possible to not only reduce fluorine emissions but also to conserve energy.

The possibility of reducing firing temperatures has been of prime interest to brick producers for several years; however, the high product quality and aesthetic requirements demanded by the current market render this approach unsuitable at this time.

In order to generate strength and durability (which are the major attributes of fired clay brick), the raw materials must be fired at temperatures which will allow some vitrification (fusion) to occur. This fusion produces a glassy phase which acts to bond particles together and produces a strong, cohesive product. The proportion of the glassy phase and the bonding achieved control the absorption properties, the durability and the compressive strength. These properties are designated by the Canadian Standards Association and in order to meet current demands in the marketplace the highest quality is generally required. Reducing the firing temperatures would have the effect of reducing compressive strength, increasing absorption levels and porosity and reducing durability unless some compensatory action was taken.

5.3.2 Changes to the Kiln Temperature Profile (Rate of Heating)

Recent laboratory studies by Tunker and Schmidt⁵¹ and Köther & Pauls⁵² on emission rates for fluoride evolution have indicated that modification and control of the kiln temperature profile rather than simple reduction of the firing temperature (particularly in the range of 800°C - 1000°C) may provide a means of reducing and/or controlling fluoride emissions from ceramic plants.

Their studies have shown that the rate of the fluoride emission is not constant with temperature rise. It is dependent upon a number of variables, the most important of which is the concentration of water vapour in the kiln atmosphere. The emission of fluoride is also independent of the total fluoride content of the raw materials (i.e. all of the fluoride is not necessarily emitted during firing). While fluoride evolution commences in the range of 550°C to 750°C, the rate of evolution increases markedly at temperatures greater than 850°C and is completed before the final firing temperature is reached. The cessation of fluoride emission is considered to be due to the onset of vitrification, which seals up the body thus preventing further diffusion of fluoride-bearing gases to the surface. The following conclusions can be drawn from their work:

- (i) Minimization of the water vapour content in the kiln atmosphere will reduce fluoride emissions.
- (ii) Air leaks into the kiln must be minimized since they require increased energy to maintain temperatures and this combination results in the presence of additional water vapour.

(iii) Reduced firing temperatures are unlikely to reduce fluoride emissions. On the contrary, it has been shown that "under firing" with approximately the same water content in the kiln atmosphere will result in considerably higher fluoride evolution (due to higher porosity and lack of vitrification in the products and greater diffusion of fluoride bearing gases from the interior to the surface of the products).

(iv) Because the rate of fluoride evolution is particularly rapid above 850°C , it would be beneficial to heat the products from 850°C to the required final firing temperature as quickly as possible, thereby minimizing the period during which fluoride evolution can occur, and ensuring the rapid onset of vitrification to seal up the pore structure of the product.

It is noted that prior to the implementation of (iv) above it will be necessary to ensure that all carbon impurities are totally burned out. Consequently, it may be necessary to incorporate a holding zone into the kiln profile to ensure total oxidation of such impurities at a temperature slightly below 850°C (e.g. 750°C). Alternatively, oxygen injection could be employed to ensure oxidation of carbon.

(v) Even though an accelerated heating rate in the region of 850°C to the final firing temperature will result in a surge in fuel consumption; the total gas consumption per unit production for the entire firing cycle may be less due to faster kiln throughputs.

5.3.3 Changes in the Kiln Atmosphere

5.3.3.1 It is evident from much of the foregoing information that the presence of water vapour in the kiln atmosphere has an adverse effect on fluoride emissions. Thus control of the water vapour content in critical fluoride-emitting zones of the kiln could influence fluoride emissions. However, in addition to noting the importance of the concentration of water vapour in the kiln, the C.B.A.C. Task Force Visit to Europe* identified that, as a result of their reversible nature, the reactions causing fluoride emission are also controlled by the equilibrium concentration (vapour pressure) of the fluorine-bearing gases in the kiln atmosphere.^{62,63}

Thus, three factors can be identified as being primarily related to the rate of fluoride evolution during firing:

- temperature;
- water vapour, and
- partial vapour pressure of fluoride-bearing gases.

Consequently, in order to bring about repression of fluoride emission, a model can be postulated comprising manipulation of three conditions:

- the movement of the ware as rapidly as possible through the kiln zone where temperatures of 850°C to 1000°C are experienced;
- the development of a stationary zone in the kiln atmosphere where a relatively high concentration of fluoride-bearing gases is permitted to form, and
- the exclusion of water vapour from this high fluoride zone.

* C.B.A.C. Task Force Visit to Europe - Reports by J.F. Nicks and J. Storer-Folt. See Appendix.

The creation of such a combination of firing conditions is considered feasible in a tunnel kiln using similar approaches to those taken in ceramic firing technology where reactions with controlled components of the kiln atmosphere are used to create special properties and effects. For example, in the brick industry itself, creation of a controlled reduction zone in the kiln atmosphere is widely used in "flashing" to produce desirable colour effects.

No indication was found in the literature, nor was any evidence found by the Task Force, that active research is currently being conducted in this area. It is recommended that research be initiated to develop the means to control fluoride emissions by manipulation of the kiln temperature-atmosphere conditions. The following items will require consideration:

- The basic chemical and physical parameters involved;
- Means to develop and control a static, fluoride containing atmosphere;
- The effects of firing profiles on fluoride emissions and on vitrification;
- Means to prevent water vapour entering the fluoride-suppression zone;
- The effects of such process changes on the cost, product quality, and energy consumption of the brick-making process.

5.3.3.2 An alternative to such gross changes in kiln atmosphere control is the local control (on an individual brick basis) of the atmosphere within and around each brick. Such an alternative has been suggested although there is little or no technical literature to support it.

It has been shown * from studies at the Institute for Silicate Research in Wurtzburg, Germany, that changing the kiln fuel from gas to oil to coal is accompanied by a reduction in the release of fluoride. The Haessler Company of Germany apparently take advantage of this effect by a novel process in which they incorporate ground coal (or any other potential solid fuel) into the centre of the brick.⁶⁴ The ground coal provides a source of energy, localized high temperatures to help seal the brick and local high concentration of fluoride to suppress evolution from clay raw materials. The lack of technical literature supporting this approach suggests a need for research to confirm or refute the concept.

Areas that would also require study include the effects of additives upon the fired colour of the product, and the plasticity and forming characteristics of the raw material mix.

5.4 Exhaust Gas Control Systems

Two techniques, widely proposed for the removal of fluorides from waste stack gases are:

- (i) wet gas scrubbing to remove soluble fluorides, and
- (ii) dry sorption of gaseous fluorides.

The majority of test work conducted to date has been carried out in Germany where the industry appears to be moving to the use of dry sorption methods.* Technology used in France* is based upon experience gained in control of emissions in the aluminum industry and is consequently based upon wet scrubbing. Whereas, in France successful

* C.B.A.C. Task Force Visit to Europe - Reports by J.F. Nicks and J. Storer-Folt. See Appendix.

application of wet scrubbing methods has been generally reported, German experience has been much less successful. U.S. experience** is limited and aimed at control of sulphurous emissions by wet scrubbing; fluorides are simultaneously removed (at least partially) by such systems.

The only Canadian experience of emission control in a ceramic plant is a wet scrubbing operation applied at a porcelain enamel plant in Ontario.⁶⁵

5.4.1 CBAC Industrial Task Force Observations

A very limited number of gas cleaning facilities were found to be operating in those countries that were visited by the CBAC Task Force (e.g. 6 - 8 plants in West Germany out of a total of 600).

Plants operating gas cleaning equipment, including pilot operations, are doing so principally to take care of specific environmental problems - fluoride, hydrochloric acid, sulfur dioxide, odor, etc. (where the fluoride removal was secondary in many instances). Generally, in Europe there is a reliance on higher chimneys for the dispersion of emissions.

Other important considerations regarding emissions are:

- (a) the size of plant, which affects the scale of any problem;
- (b) the location of plants, i.e. concentration of industry, agriculture, etc.;
- (c) the physical conditions, i.e. topography, prevailing weather conditions, etc.

** C.B.A.C. Task Force Visit to U.S.A. - Reports by H. Penn. See Appendix.

Generally, existing works are not subject to compliance, in the strictest sense, unless there is evidence of loss or damage due to fluoride emissions.

Details of fluoride control methods and the principles of their operation are discussed in the following sections.

5.4.2 Wet Control Methods

According to Wilson,¹⁶ the fluorine-bearing components that have been identified in kiln exhaust gases are highly soluble in water and can, therefore, be relatively easily removed from the gas stream by water scrubbing techniques. He cites the control of fluoride release from the treatment of phosphate rock to produce phosphoric acid and fertilizers as typical examples of the degree of control which can be attained.

5.4.2.1 German Experience has, however, suggested that the control of brick kiln emissions by wet scrubbing is more difficult to implement than the control of emissions from phosphate fertilizer manufacturing. Work has been in progress in Germany for several years to adapt conventional wet scrubber technology to brick kiln applications and has met with minimal success,^{56,66,67,68} the general concensus being that although the principles are sound, the current state of engineering practice is inadequate to meet the demands of the German Clean Air guidelines at an acceptable cost. Unforeseen corrosion problems combined with a failure to find a solution to the waste water and neutralized sludge disposal problems, have resulted in such heavy financial expenditures for the installation and operation of scrubber systems that they had to be removed. Typical installation costs are reported to have been from 300,000 and 500,000 DM.

It was reported by the CBAC Industry Task Force that a wet, condenser gas cleaning system had been installed at the Carl Möller Company in Germany. However, at the time of the Task Force visit, the system was not in operation. It was reported that one condenser unit had been recently replaced using corrosion resistant materials as the original unit had failed.

A detailed and authoritative report on the problems associated with a variety of wet scrubbing systems in use in the German heavy clay industry has been presented by Mueller.⁶⁸

Mueller has considered four classes of wet scrubbing systems:

- (i) a wet electrostatic filter system;
- (ii) a wash tower with a perforated plate base and impact plate wash-tray;
- (iii) a vortex scrubber; and
- (iv) a jet gas washer.

In summary, Mueller emphasized the following factors:

- The efficiency of such scrubbers did not always meet the rated design values, some of which were only achieved over a short period, but not over days and weeks of constant operation.
- In all cases, major failures and repairs were common, and in three of the four techniques employed, stacks and stack linings failed and had to be rebuilt or replaced after short periods of operation.

Meuller believed that these examples served to show the problems which exist with the use of scrubber plants in the heavy clay industry. He also believed that every new flue gas purification plant is constructed for a highly specialized case and must be exactly tailored to the individual application and should be evaluated on a pilot scale prior to installation.

In closing out his assessment of the application of wet scrubber technology to the heavy clay industry, Meuller made the following statements:

"Above all, the high level of wear and tear and replacement of piping, fan, pumps, and chimneys in particular, have not yet been reduced to economic proportions. Repairs involve interruption not only of the scrubber plant itself but also of the entire kiln, as the draught in the kiln must be adjusted or maintained constant via the washing plant, and thus quality will probably be affected or production curtailed.

"Because the flue gases fall below the dewpoint after scrubbing, with associated condensation, their corrosiveness becomes so high that existing chimneys can no longer be considered adequate for the dispersal of the residual emissions, and a new corrosion-resistant chimney has to be built. In the case of a breakdown in the scrubber plant, however, this chimney cannot be used for the discharge of the flue gases at temperatures of 150°C to 250°C, in this event a traditional chimney is required instead.

"Scrubber plants certainly correspond to the current state of engineering practice in certain industrial sectors in which relatively well-defined flue gas conditions are to be found, where either dust or sulphur dioxide or fluoride has to be separated and where, in addition, the sulphur trioxide component is low. In the heavy clay industry, however, where a heterogeneous mixture of waste gases and combustion products exist together and considerable variations are to be found, the use of scrubber plants is still associated with so many unknown factors that their employment within brickworks involves an unduly high risk.

"Scrubber plants constructed so far have not proved satisfactory under the conditions prevalent in the heavy clay industry and trials with them were not successful.

"In addition even when a company has a special chimney built for the scrubber and the dispersal of the residual emissions, the problems attached to gas purification plants are not yet over. Before being discharged into the sewer system, the washing effluent must first, if at all possible, be neutralized. Usually the salts dissolved in the washing liquor are precipitated with calcium hydrate followed by separation of liquid and solids by boiling concentration. Finally, there is the problem of the transport of the solid sludge and its deposition at a suitable disposal site. The process costs involved from the effluent disposal to the disposable sludge are twice as high as the cost of the actual scrubber plant."

5.4.2.2 French Experience is limited to the efforts of a single company^{64,69} (see Appendix on Task Force Visits) and in general largely contradicts the German findings. The Ceric Company, (a major French company manufacturing kilns, clay working equipment and complete ceramic plants) have used a process originally designed by Peabody-France for emission control on the aluminum smelters of the Pechiney Company. The process uses sodium hydroxide in a wet neutralization system. For plants unable to discharge liquid pollutants, an add-on stage designed to precipitate calcium fluoride, is included. The CaF_2 can be filter-processed and discarded to a solid waste landfill site. Sodium hydroxide is regenerated for re-use as follows:



Although the system appears simple and efficient, it has mainly been used at small installations, which appear to be working satisfactorily.

It is reported⁶⁹ that a system has been installed in a major brick and roofing tile plant in Toulouse and is said to be operating successfully. This system has been judged by Industry Task Force Members to be a thermally efficient and cost effective method of reducing fluoride emissions.

5.4.2.3 North American Experience*^{64, 69} is very limited in the field of wet scrubber technology as applied to heavy clay technology or other ceramic plants, and reference is generally made to the fertilizer industry¹⁶ assuming that the industry's technology is directly transferable. German experience indicates that this is unlikely to be the case.

It is known that at present, Interstate Brick Division in West Jordan, Utah, has a water scrubbing system designed to remove sulphurous gases from its exhaust stacks. The scrubber comprises of a 60 ft. stack with plastic strips through it to increase the contact surface area and two ponds approximately 20,000 ft.³ in volume. The exhaust gases pass through the stack in counter-flow to a water spray which dissolves acidic sulphur and fluoride bearing components. The solution collected at the bottom of the stack is drained to the ponds where the pH is adjusted with limestone. The cost of this system was reported to be 40 to 60 thousand dollars. Although the system is not

* C.B.A.C. Task Force Visit to U.S.A. - Report by H. Penn. See Appendix.

sophisticated, it could be used for the control of low concentrations of fluorides.

The Chicago Vitreous Company⁶⁵ (porcelain enamel manufacturers) located in Ingersoll, Ontario, use a more sophisticated wet scrubbing system than those previously discussed. A two-stage refining approach is employed. In the first stage, water jets spray the fluoride gases as they pass through a chamber; the water is then drained to large holding tanks and the stack air is further refined in a second chamber with a venturi system. The water is again drained to large holding tanks with the purified air exhausting up the stack. The water in the holding tanks is neutralized by additions of lime; the resulting CaF_2 is mechanically filtered and dried. A one million dollar cost is required to have the system installed and an additional \$56,000 per year is needed to maintain it in operation. Results to date with this equipment are somewhat mixed and opinions of its efficiency vary.

The Globe Refractories Company has employed an ionizing wet scrubber system to eliminate ammonium bisulphate emissions from the exhaust of four tunnel kilns at their refractories plant in Newell, West Virginia.^{70*} In addition to removing ammonium bisulphate, the scrubbing system also removed 99% of HCl and HF and exceeded expectations in the removal of SO_2 . Before installing the system, the Company conducted a number of pilot plant studies on other systems which included bag filters (coated and uncoated), ammonia injection, dry electrostatic precipitators, high energy scrubbers and mist eliminators. (See Appendix for operating and equipment details.)*

* C.B.A.C. Task Force Visit to U.S.A. - Report by H. Penn. See Appendix.

In total the Company expended some \$4.5 million in evaluation and construction of pollution control systems within a 6 - 8 year period to bring the system to a satisfactory conclusion.

In addition to the above, it has been reported that Klein Brick of Kentucky⁷¹ and the Dickey Co. in Florida⁷² both utilize some forms of wet scrubber for fluoride removal; however, no information on the nature of the system or its efficiency is available.

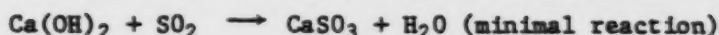
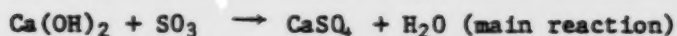
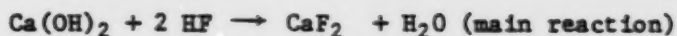
5.4.3 Dry Sorption Techniques

The reduction of fluoride in flue gases by means of dry sorption techniques is already well known in the aluminum industry¹⁶ and recent studies by the German Brick and Tile Research Institute⁶⁸ suggest that it could have great practical value to the heavy clay industry. Numerous articles have been published referring to this approach and to plant trials^{67, 68, 73, 74, 75} in Germany and it would appear that the general consensus of the industry is that this approach, although still in its design infancy, shows the greatest potential of any of the exhaust gas control systems in meeting clean air guidelines. However, it should be realized that whereas gaseous fluoride emissions may be reduced by this technique, the possibility exists for increased particulate emissions, and some form of de-dusting will be required.

The high affinity of acidic gases for alkali earth oxides and hydroxides (particularly calcium hydroxide) form the principle of dry sorption techniques for flue-gas cleaning. Thus the process requires only that the two materials (flue gas and absorptive medium) be brought together under suitable physical and mechanical conditions

to convert highly corrosive gases into relatively inert insoluble solid phases such as calcium fluoride (CaF_2) and gypsum (CaSO_4).

Typical reactions taking place during dry sorption in an exhaust gas stream are:



Satisfactory results⁷⁴ have been obtained using soft burned or hydrated lime as the sorption medium and injecting it into the waste gas flue with subsequent collection of the solids on cloth filters. Experiments are also in hand to re-use the precipitated lime dust from the filter to reduce disposal problems.

Major advantages of this technique over wet scrubbing systems are its lower cost, the reduction of effluent disposal problems and significantly reduced corrosion phenomena. In addition efficiencies of up to 95% removal of fluorine have been reported⁷⁵ by Jepsen & Sendatzki who conducted a very detailed study on fluoride removal by dry sorption using injections of calcium hydroxide into a horizontal reaction path, together with a cyclone dust collector.

More recently, Pauls⁷⁶ has reviewed flue gas cleaning systems currently employed or under development in Germany and has confirmed that dry sorption systems using injection of calcium hydroxide appear to be the most practical at this time. However, Pauls cites condensation processes currently being researched as having great potential if material performance problems can be overcome. These are considered to offer potential advantages in respect of



economy of performance and a potential for energy recovery.

A new potential process for gas absorption has been reported⁷⁷ which uses limestone rather than calcium hydroxide as the absorbent. It is reported to offer the following advantages:

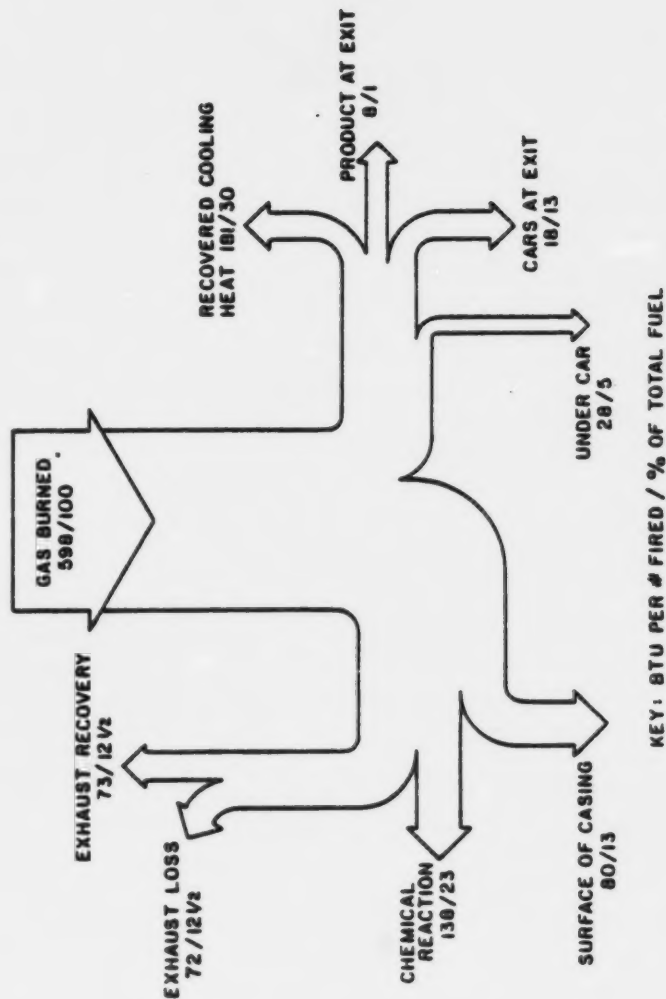
- High degree of absorption;
- Automatic process flow;
- Minimum consumption of supplemental energy, and
- Reasonable capital and operating costs.

The system uses a drum containing cells filled with loose layers of limestone, through which the exhaust gas stream flows. By rotating the drum, attrition of the limestone lumps provides the absorption medium in the form of powder which picks up the pollutants and is carried away to a dust collection system. Materials other than limestone can be used to improve efficiency or remove other polluting species. Variations on this system include rotating filter beds where gases pass through the bed of absorbent rather than over the surface.

The reports of the C.B.A.C. Task Force Visit to Europe (see appendix) describe systems currently in use or in development in Germany which are not otherwise available in the technical literature.

EXHIBIT 6.2

SANKEY DIAGRAM FOR INDICATED AREAS OF ENERGY CONSUMPTION
AND LOSSES



6. KILN EFFICIENCY AND FLUORIDE CONTROL

6.1 General Consideration and Constraints

For high capacity and efficient production of heavy clay products, tunnel kilns must be considered the workhorse of the North American industry. In Canada, virtually all production is now achieved using tunnel kiln firing with natural gas. The exceptions are some older plants in Quebec and the major Maritime producer (L.E. Shaw Ltd.) which uses some high efficiency periodic kilns. However, it is anticipated that all future major developments in firing technology for heavy clay products will be addressed to the use of tunnel kilns. Thus, for the purpose of this review, discussions will be limited to the potential impact of fluoride emission control on the energy efficiency of tunnel kilns.

6.2 Energy Efficiency of Tunnel Kilns

6.2.1 North American Experience

The primary concern in firing of clay bricks is to produce a high quality product while using the minimum fuel possible. If we consider the energy input to a kiln, then it is clear that only a fraction is used to heat the load and ensure completion of the required ceramic reactions; the balance is discharged as flue gas losses, heat required to raise the temperature of the kiln furniture and cars, and heat losses through the walls of the furnace itself. It is common practice to recover some of this 'lost' heat by diversion of hot air from the cooling zone to the drying stage of the operation and also by using it to preheat incoming air.

A schematic drawing showing a typical kiln thermal balance is shown in Exhibit 6.2.⁷⁸ Specific energy consumption depends upon

kiln design and operating procedures, however, the drawing indicates the typical order of magnitude for energy consumption and losses.

Improvements in kiln efficiency have been attained largely by reducing or eliminating the various sources of heat loss, or in some cases by deliberate recovery of waste heat.

In order to achieve lower production costs, improved thermal efficiencies and energy conservation, North American kiln manufacturers and plant operators have employed a variety of approaches to kiln design and operation. In recent times, these have included combinations of the following:

- installation of more efficient top-fired tunnel kilns as opposed to conventional less efficient⁷⁹ side-fired tunnel kilns for new plants.
- installation of very-wide tunnel kilns (e.g. 24-brick wide kilns which are three times wider than conventional older kilns) - such kilns have lower structural heat loads and losses.
- application of pulverized solid fuel firing techniques to permit the use of less expensive fuels such as sawdust and coal in preference to natural gas and oil.
- application of lightweight fibre refractory linings to the furnace crown⁸⁰ and the burner zone.⁸¹ Fuel savings of up to 20%⁸² or more have been reported for periodic kilns while figures of 7% have been quoted⁸¹ for continuous tunnel kilns.
- control of the air/fuel ratio⁸³ to ensure that combustion reactions are complete.
- injection of oxygen or application of oxygen-enriched air to furnace burners. It is reported⁸⁴ that fuel consumption can be reduced by up to 15% while production rates can be increased by up to 10% by application of this approach. Savings are reported to occur in three ways:

- (i) burners operate at reduced firing rates because the kiln temperature profile can be lowered throughout the oxidation zone without adversely affecting carbon burnout.
- (ii) stack losses are significantly reduced because total volume of exhaust products is minimized.
- (iii) higher oxygen concentrations resulting from the oxygen injection system accelerate the carbon burnout reaction and permit faster production rates without the danger of "black coring".

The economics of oxygen injection are still under review.⁸³ It is considered that in some cases, the economies obtained will not merit the expenditure on oxygen and equipment required to implement the process.

6.2.2 Canadian Experience

As has been previously stated, total energy consumption, per unit of product, in the Canadian heavy clay products industry was reduced by 27.8% between 1975 and 1981 (refer to Exhibit 1.2). Of this energy consumption, 85 - 95% is fuel for firing, 7 - 10% is electrical power, and 1 - 5% is miscellaneous other energy costs associated with plant operations, such as propane for fork lift trucks and gasoline for truck haulage, etc.⁸⁵ From these values, it is obvious that the major economies have been achieved in the area of kiln-fuel efficiency.

These achievements have been gained through programs which had four main aims:

- (i) the reduction of heat input to the process;
- (ii) the maximization of heat recovery and recycling within the process;
- (iii) the reduction of stack discharge temperatures to minimum practical levels consistent with maintaining gaseous discharges above the dew point;
- (iv) the reduction in the volume (mass) of hot gases discharged.

The approach to these changes in procedure varied from company to company and from plant to plant within any given company to accommodate individual engineering and process constraints. However, major contributing factors which have been identified are:

- changes in burner design
- application of high velocity burners - to increase thermal turbulence and improve heat penetration into kiln load
- changes in burner operation, i.e. operating at optimum air/gas ratios - minimum excess air
- changes in kiln structure and engineering
- improved insulation of kiln walls and crown
- optimal installation of fans for heat recirculation and use of waste heat
- installation of flat arches and baffles to drive hot gases into load
- application of heat reflective surfaces within kilns
- improvement in air seals to prevent infiltration of tramp air
- incorporation of burnout fuel as raw material component (e.g. fly ash, sawdust)
- manufacture of lighter products - by increasing core volume

- changes in load setting for optimal heat transfer
- construction and application of lighter kiln cars - to reduce thermal losses incurred in non-productive heating and subsequent cooling of kiln cars
- changes in thermal profile of kiln, (heating rates, cooling rates and soak times)
- faster production rates
- application of higher firing temperatures for shorter time periods.

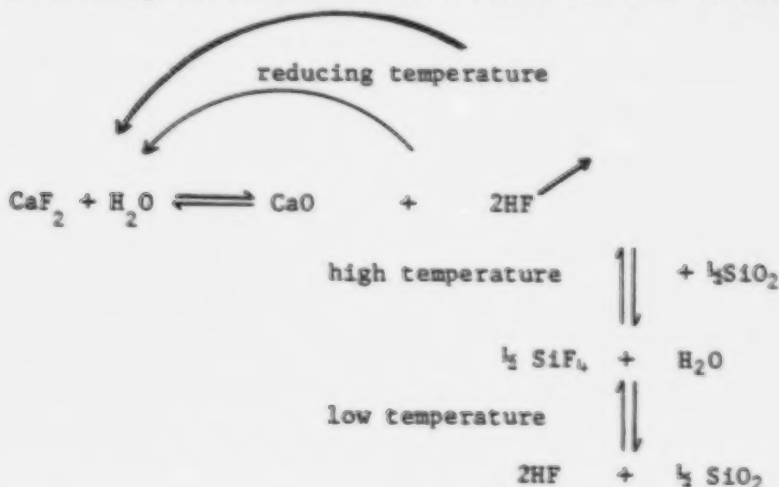
6.3 Impact of Fluoride Emission Control on Energy Efficiency

If the means to fluoride emission control are considered in detail, it is clear that a priori one should anticipate that such changes in procedure from those normal to the operation of a tunnel kiln should have some significant impact upon the energy consumption of the brickmaking process. It is thus somewhat surprising that only one reference was found in the literature relating fluoride emission control and energy impact. A report by Tunker and Schmidt⁵¹ makes reference to potential energy savings that might be found during firing when a rapid heating thermal profile is used to reduce the time that ware is exposed to the 'maximum fluoride emission' phase of the firing process.

The present authors consider that any method of limiting, or controlling fluoride emissions from brick plants, whether it be by raw material source control, modification of the firing schedule or process or exhaust gas control systems, will have some impact upon the energy consumption during the firing process. In some cases, the effect may be minimal, in others it may be significant; in either case the effect may be beneficial or deleterious.

If one considers the following reaction as typifying fluoride emission during the firing process, it is possible to assess probable impacts which would occur for each method of control.

Increasing CaO content and HF concentration at surface



6.3.1 Impact of Raw Material Control

To date, suggested approaches to raw materials control have included the incorporation of lime (CaO) or waste metal hydroxides into the body formulation. The anticipated impact of such an approach is:

- (i) the firing temperatures may need to be increased to maintain the desired physical properties of fired products;
- (ii) the raw material mix may require additional tempering water for optimum extrusion; this will give rise to increased energy requirement in drying, and may possibly affect green strength and subsequent production losses caused during direct setting operations.
- (iii) the fired product may retain higher porosity levels to much higher temperature during firing thereby allowing potential for even greater fluoride evolution.

6.3.2 Modification of Firing Schedule or Process

Since this approach is directly concerned with alterations to the fuel input or kiln operation, major changes in fuel efficiencies are anticipated. In general, it can be expected that any changes which result in an increased rate of heating and thus, an increased rate of production will have a beneficial impact on energy conservation. Consideration must also be given to maximum drying rates, cooling rates and overall kiln design. Any change which requires slowing down the heating rate (or production rate) or which requires extensive soak times at elevated temperatures will have a negative impact on energy conservation.

Any changes to kiln firing schedules that could cause an increase in production losses, either in respect of reduced rates of production or increases in the proportion of defective bricks produced could seriously reduce the energy efficiency of brick manufacturing. All such losses are potentially deleterious to energy efficiency, however, such a possibility is of particular concern where clays or shales containing high quantities of lime-bearing impurities are used. As Bell⁸⁶ has shown, some Canadian brickmaking clays of this type are susceptible to cracking when subjected to rapid temperature gradients in the preheat (800 - 900°C) zone. Thus, to maintain or improve energy conservation while controlling fluoride evolution by modification of the firing schedule, careful control of the kiln variables and optimized heat transfer within the kiln load are of paramount importance.

6.3.3 Exhaust Gas Emission Control Devices

The incorporation of exhaust gas emission control devices whether they be wet or dry will almost certainly result in an energy penalty for the firing process. While the magnitude of such penalties are hard to estimate at this time for the kiln operation itself, there will, of course, be indirect energy penalties (e.g. electricity) just to operate the control systems.

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Final Report

EXHIBIT 6.3

ANTICIPATED ENERGY IMPACT OF FLUORIDE EMISSION CONTROLS

Contributing Factors To Energy Efficiency	MEANS OF CONTROLLING FLUORIDE EMISSION							
	Raw Materials			Firing Modifications		Exhaust Gas Control		Product Modific- ation
	Removal of Fluoride Minerals	Additives		Fast Firing	Local Atmosphere Control	Wet	Dry	
COMBUSTION CONTROL (including air/gas ratio, use of high velocity burners, preheated air)	0	0	0	/	/	/	/	0
KILN SETTING (density of kiln load)	0	0	0	/	/	0	0	/
HEAT RECOVERY (recirculation of waste heat, elimination of tramp air, reduction of moisture, reduction of exit gas temperature)	0	0	0	/	-	/	/	0
THERMAL PROFILE (faster production rate, higher/lower firing temperature)	0	-	/	+	-	/	/	/
INCORPORATION OF SUBSOUT FUEL (e.g. fly ash, coal, saw dust other biomass)	0	0	/	-	?	?	?	/
LIGHTER PRODUCT (higher core volumes)	0	0	+	+	?	?	?	/
KILN ENGINEERING (construction, materials, etc.)	0	0	0	/	/	/	/	?
INDIRECT ENERGY INPUT (plus chemicals and materials purchases and waste disposal)	0	0	0	0	/	/	-	?

KEY

- 0 No anticipated impact upon energy efficiency of tunnel kiln
 - / Anticipated effect but nature unknown
 - ? Not known if any effect likely
 - +
 -
- Anticipated positive effect on energy efficiency
- Anticipated negative effect on energy efficiency

However, it is expected that some heat recovery would be obtained from implementation of any wet system. It is anticipated, therefore, that the following energy-influencing impacts will occur.

- less heat will be available for recycling because temperatures within the system will need to be maintained above the dew-point.
- direct energy costs will be encountered for the operation of the system in the form of power, water, thermal and disposal costs.
- air velocity may become a factor (and may cause pressure fluctuations within the kilns).
- a by-pass flue system will be required as a back-up or alternate for periods of "downtime". Tunnel kilns cannot be instantly shut-off whenever a breakdown or fault occurs in a subsidiary system such as a scrubber.
- in the case of dry sorption systems, additional heat will be required to maintain temperatures of dust collection system above dew-point, particularly in winter.

While the above is by no means an exhaustive list of potential areas of energy impact by fluorine control procedures, it indicates areas of concern.

Exhibit 6.3 shows, in tabular form, a summary of the probable energy impacts which can be anticipated if control procedures are implemented for fluorine emissions.

7. CONCLUSIONS

The purpose of this review has been to consider the major factors involved in relation to the evolution of fluoride compounds from heavy clay products during firing, the nature of current and proposed regulations governing discharge of these emissions in Canada, the technology of control, and the likely impacts such controls might have on the energy efficiency of tunnel kilns.

It is clear that the emission of fluoride containing compounds as gaseous or particulate matter from industrial sources has the potential to present some hazard to the environment in terms of:

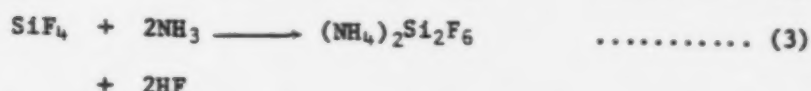
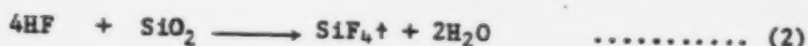
- contributing to general acidic precipitation;
- damaging vegetation;
- injuring the health of foraging animals and, in extreme circumstances, the health of humans.

It is also clear that the firing of heavy clay products is not, by any means, the only source of industrial fluoride, nor is it a source of such magnitude as some other industrial activities. However, as regulatory bodies seek to control industrial emissions, it is evident that some Canadian manufacturers of heavy clay products will be required to take action to reduce the evolution of fluoride compounds from their plants.

The origins of fluoride emission during the firing of clays and shales lie in the decomposition and subsequent reaction of mineral species contained in almost all sources of brickmaking raw materials. During the firing cycle, fluorine compounds are evolved over a range of temperatures from the clays and shales as hydrogen fluoride, silicon tetrafluoride and other complex fluorides.

Although the evolution of fluorides is complex and is not completely understood, it is clear that a number of fundamental chemical and processing factors are influential in determining the rates at which fluorides enter the kiln atmosphere (and hence ultimately their discharge with the stack gases). Most notable are the following:

Reactions



Rate Influencing Factors

- (1) Elevated partial vapour pressure of water increases evolution rates (Reaction 1)
- (2) Elevated partial vapour pressure of fluorine compounds (Reactions 1 and 2) decreases evolution rates
- (3) Physical factors related to porosity, permeability and mass diffusion influence the mass transport of fluorine compounds and affects evolution rates
- (4) Elevated temperatures (below the temperature of vitrification) increases evolution rates

The control of fluorine compound emission from a kiln can be approached in one or more of three ways:

- selection of raw materials of reduced fluoride emission potential (including additives for suppression of fluoride evolution);
- alteration of the firing procedure to reduce the rate of fluoride evolution;
- control of gaseous emissions at the stack by means of scrubbers.

Upon completion of their visits to foreign plants, the C.B.A.C. Industrial Task Force expressed the following opinions:

- (a) The employment of flue gas cleaning systems should be regarded as the last step in emission control and every plant should be treated as a specific case dependent on all the technical factors.
- (b) The most productive approach to reduce F^- emissions is to take a preventative approach through raw material alteration and modifications to processing procedures.

It is the opinion of the authors that at the present time, the following assessment may be made of the practicality of the available control measures:

- selection of alternate low fluoride raw materials is largely impractical in Canada for reasons of geographical location of existing plants and the limited availability of alternative sources. The use of additives and fluxes in raw material blends may, however, prove to be practical.
- as was noted by the C.B.A.C. Industrial Task Force, the most practical approach to control of fluoride emissions would appear to involve changes in the firing process to reduce fluoride evolution at its source.
- because of operational and corrosion problems, the existing exhaust gas emission control technology may prove unreliable for use by the Canadian Industry and could incur a significant energy penalty.

Although it is clear on an a priori basis that the use of additives and fluxes, changes in thermal profiles or kiln atmosphere conditions or the introduction of scrubbers on kiln exhaust systems, must have impact upon the energy efficiency of the production process, there would appear to be no significant information presently available either from literature sources or from industry sources in Europe or North America. It is the opinion of the authors that a program of research is required to develop and evaluate the more

promising options for fluoride control with particular reference to understanding the nature and magnitude of their impact on energy efficiency. The objective of such a program should be the preparation of industry guidelines to assist the clay brick industry in selection of suitable energy-efficient fluoride control methodology. A proposed program to this effect is presented in Section II of this report.

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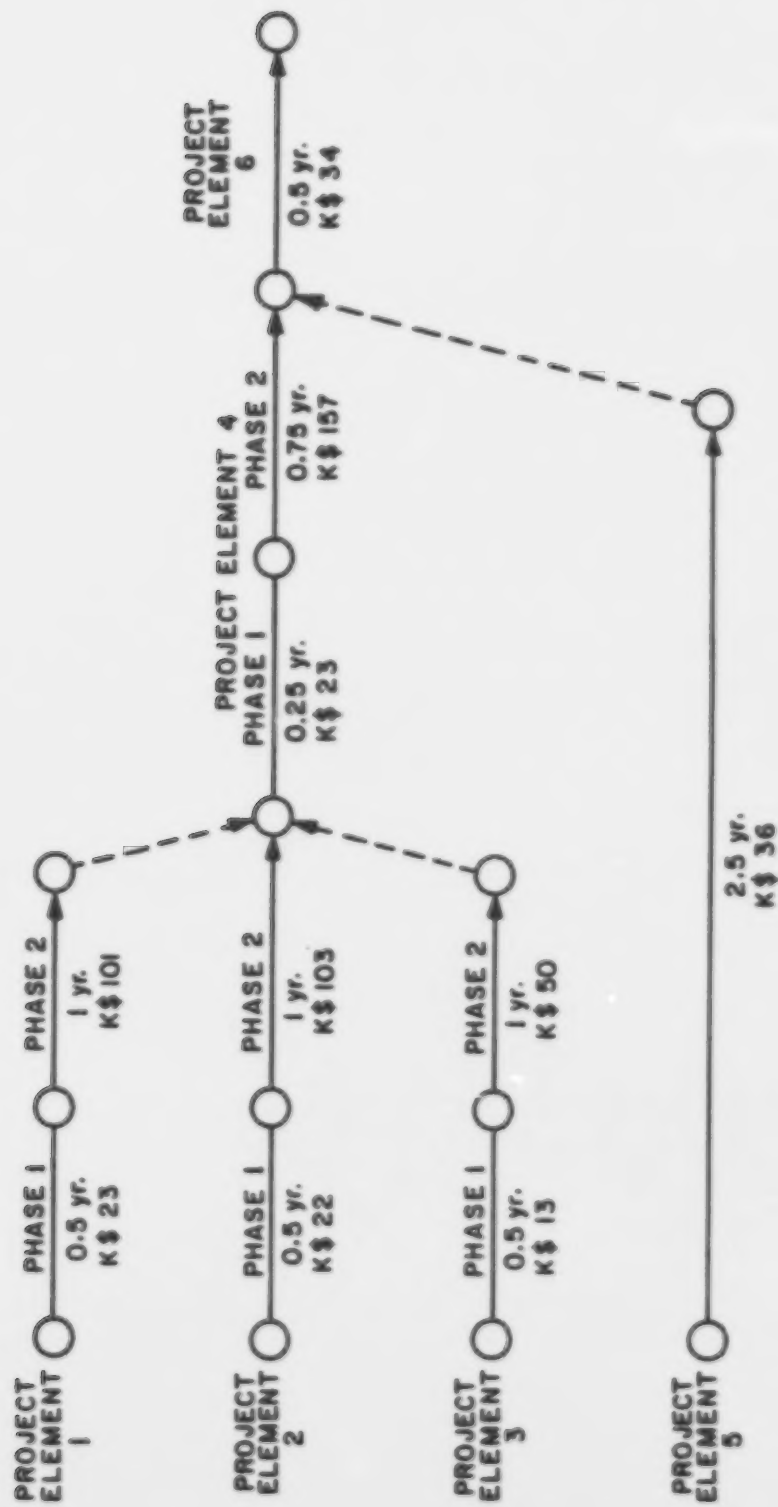


Clay Brick Association
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SECTION II

PROPOSED PROGRAM OF RESEARCH AND DEVELOPMENT

FIGURE 1



1. INTRODUCTION

On the basis of the findings of the preceeding critical review and the reports from the CBAC Industrial Task Force, it is recommended that CANMET, in conjunction with the clay brick industry, establish a research program. The objective of which should be the development of technical guidelines for use by the brick industry to assist in the control of fluoride emissions by practically applicable methods having minimal negative energy impact on the firing processes.

It is considered that the necessary data can be obtained through a research program comprising the following six project elements.

1. Experimental examination under process conditions of the fluoride emission profiles and energy balances at brick manufacturing plants in Canada.
2. Experimental examination under controlled laboratory conditions of the effects of thermal treatment and kiln atmosphere changes on the emission of fluorides from selected Canadian brickmaking materials.
3. Experimental investigation of the effects of selected additives and fluxes on the emission of fluorides from selected Canadian brickmaking materials.
4. Experimental evaluation of the effects of process changes (designed to incorporate the findings of research implemented under 2 and 3) on fluoride emission profiles and energy balances at selected brick manufacturing plants in Canada.
5. Evaluation of new fluoride emission control technology currently under development outside of Canada.
6. Preparation of a summary review of the findings from elements 1 to 5 and development of technological guidelines for the selection of energy-efficient methods of reducing fluoride emissions from brick-making kilns.

It is expected that this program could be completed over a three-year period at a total cost of approximately \$502,000. An analysis of this proposed project is presented in outline form in Figure 1.

Details of the recommended project elements are presented below in the form of "Work Statements". Estimates of probable costs have been based upon recent experience of industry members with regard to work of a comparable nature.

Project Element 1

Objectives

This project element is intended to provide a data base on the current status of F^- evolution and energy efficiency at 4 major clay brick manufacturing facilities in Canada. This data base will be expected to permit the following items to be enumerated and evaluated:

- F^- emissions from operating kilns
- F^- input/output balances
- Energy consumption/unit production under average conditions
- Thermal profiles along the length of the kiln and at different positions in the kiln section
- Detailed thermal profiles within hack during firing
- Detailed F^- balances for selected ware as a function of position in hack during firing

Approach

It is expected that the above data will be obtained from a minimum of 4 kilns selected with regard to the following criteria:

- geological/geographical origin of raw materials employed
- type, age, size and character of kiln
- history of F^- emission

The project is expected to be conducted in two phases:

- Phase I - Preliminary industry survey, selection of kilns to be examined and design of experimentation for Phase II.
- Phase II - Detailed study on each kiln using unified testing methodology to permit comparison to be made. Reporting and analysis.

Outline of Work Required

Phase I

With the co-operation of the manufacturers, the performer(s) shall be required to survey the materials and the production facilities of all those clay-brick producing plants in Canada willing to participate. A report shall be compiled relevant to the objectives of the project and recommendations shall be made as to which plants (kilns) should be selected for detailed examination under Phase II. In conjunction with the Scientific Authority and the Technical Steering Committee a program of detailed investigation (to be implemented as Phase II) shall be designed and scheduled.

Phase II

The program design resulting from Phase I shall be implemented. The following measurements will be required to be made on at least 4 kilns.

- Total atmospheric fluorine emissions, measured by stack sampling in accordance with Provincial and Federal Guidelines, which are to include gaseous and particulate forms of emissions.
- Analyses of fluorine input/output characteristics in such a form that a material balance can be estimated under steady-state generating conditions.

- Energy audits of the kiln system
- Measurement of thermal profiles along the length and across the plane of each kiln are to be determined using travelling thermocouples mounted within at least one hack of brick during normal firing.
- Selected ware (related geometrically to the positioning of thermocouples) are to be collected from the car after the firing sequence, during which the thermal profiles are determined, and measurements of fluorine content are also to be determined. These experiments are to be conducted in such a way that a cross sectional profile of fluorine emission can be estimated for ware placed in an average car-load and fired under normal production conditions.

Characteristics of Performers

This project element will require a very considerable level of co-operation and commitment to the program on the part of the clay-brick manufacturers. It should, therefore, be co-ordinated by the Clay Brick Association of Canada.

Technical work will be required from sources having a good understanding of the brickmaking process and the capability to perform the following activities on full scale process equipment:

- energy audits;
- kiln thermal measurements using travelling thermocouple system;
- stack emissions testing;
- chemical analyses for fluorine at the ppm level;
- detailed and critical analyses of the data.

Cost and Time Estimate

It is anticipated that this work could be completed within one year. A breakdown of the estimated costs for this work is given below.

Phase I

Consultant cost, 240 hrs. @ \$75.00	\$ 18,000
-------------------------------------	-----------

Phase II

Emission tests and energy balances	40,000
Temperature profiles	20,000
Fluorine profiles	8,000
Travel	8,000
Reporting	<u>4,000</u>
	\$ 98,000
Project Management (15%)	<u>14,700</u>
	\$ 112,700
Administrative Overhead (10%)	<u>11,270</u>
	\$ <u>123,970</u>

It is anticipated that this project element could be completed in 1.5 years (0.5 year - Phase I, 1.0 year - Phase II)

Project Element 2

Objectives

This project element has as its principal objective the compilation of data on the relationships between firing rate, temperature and atmospheric factors and the evolution of fluorine from Canadian brick clays and shales. The data will be used to develop and model optimized firing and fluoride evolution profiles.

A secondary objective of the project element is to provide a practical opportunity for researchers in Canada to obtain first-hand experience of thermal methods being employed in Germany with a view to the possible transfer of the technology to Canada.

Approach

The background to the application of thermal analysis to the problems of fluorine emission has been established, along with methods of experimentation, by workers at the Institute of Silicate Research in Wurtzburg, Germany.

Samples selected to represent four general classes of brick-making materials used in Canada, will be sent to the Institute for examination and testing. A Canadian research scientist, established in the field of clay brick technology and with a working knowledge of the chemical techniques involved, will spend time in Wurtzburg learning the methods used and reviewing the results of the German research on this topic. The knowledge obtained will then be applied to the development of a capability for modeling optimized firing conditions for Canadian brick kilns.

A complete review of fluorine evolution profiles will be made for ten additional brickmaking materials currently being commercially employed in Canada. These data, in combination with those obtained during the implementation of project element 1 will then be employed

to derive theoretical optimized firing curves for each clay/shale while ensuring minimal fluoride evolution.

Outline of Work Required

Phase I

A minimum of four samples of brickmaking materials will be collected by a selection process aimed at obtaining materials representative of the principal classes of clays/shales used in Canada.

These materials, after suitable preparation of specimens, will be sent to the German Institute of Silicate Research for thermal investigation of fluorine emission profiles.

The selected Canadian researcher will spend as much time as is required at the Institute and will prepare a report addressed to the following items:

- the results and their interpretation with regard to the behaviour of the samples of Canadian materials examined;
- a complete description of the methods, equipment and analytic techniques used at the Institute for examination of fluorine evolution;
- a comprehensive review of the interpretation of data employed by the Institute as a means to compute optimized firing curves.

Phase II

The methods and data evaluated during Phase I could be used to establish a similar Canadian capability for use by the clay brick industry. Applied research programs will be conducted on the nature and potential control of fluorine evolution from up to 10 further Canadian brickmaking clays and shales using thermal profile techniques. These research programs will need to be designed in detail after the completion of Phase I but are expected to address at least the following items:

- examination of ten Canadian brickmaking materials used in significant quantities;
- examination of the chemical/thermal parameters relevant to the thermal control of fluorine evolution;
- development of models suitable for the computation of preliminary optimized firing curves that can then be tested during the progress of project element 4.

Characteristics of Performers

1. The experimental work in Phase I will be carried out under sub-contract by the Institute of Silicate Research, Wurtzburg, Germany.
2. The Canadian researcher will be selected on the basis of established competency in:
 - clay brick chemistry
 - knowledge of brickmaking technology
 - fluorine chemistry
 - thermal analysis
 - access to computer modelling capabilities

Association with an established laboratory active in similar research would also be expected, eg. University, government or independent contract (consultant) laboratory. A demonstrated ability in communicating technical information (technology transfer) will also be required.

Cost and Time Estimates

Phase I

80 hrs. @ \$75.00	\$ 6,000
Fluorine profiles 4 x 2000	8,000
Travel	<u>3,500</u>
	\$ 17,500

Phase II

Fluorine profiles 10 x 2000	\$ 20,000
Interpretation 14 x 500	7,000
Development of Models	50,000
Reporting	<u>4,000</u>
	98,500
Project Managment (15%)	<u>14,775</u>
	113,275
Administrative Overhead (10%)	<u>11,328</u>
	124,603

It is anticipated that this project element will require work over a period of 1.5 years.

Project Element 3

Objectives

This project element, in the form of an applied research project is expected to provide fundamental background information as to the nature and probable efficacy of materials that might be added to brickmaking raw mixes to reduce the amount of fluorine evolved during firing.

Approach

An applied research project is required to examine the theoretical and experimentally determined efficacy of additives and fluxes to reduce F^- evolution by such mechanisms as:

- F^- capture
- partial sintering
- porosity reduction

Performer

University or other research laboratory equipped for, and experienced in ceramics materials research.

Cost and Time Estimates

Theoretical Analysis	\$ 10,000
Laboratory R & D	25,000
Fluorine profiles 5 x 2000	10,000
Reporting	2,500
Travel	<u>2,000</u>
	49,500
Project Management (15%)	<u>7,425</u>
	\$ 56,925
Administrative Overhead (10%)	<u>5,693</u>
	\$ 62,618

It is anticipated that this project element could be completed in 1.5 years.

Project Element 4

Objectives

To apply and demonstrate, under plant scale conditions, the application of firing modifications developed during implementation of Project Elements 2 and 3.

Approach

A program conducted in two phases is envisaged as follows:

Phase I

The first phase will comprise a review and co-ordination of data from Project Elements 2 and 3 and preparation of an experimental design for Phase II.

Phase II

Full scale plant trials of effects of selected process modifications at the four plants (kilns) used during Project Element 1 conducted in the same manner using the same methods.

Preparation of reports of findings including recommendations and draft guidelines for their implementation.

Performers

As Project Element 1.

Cost and Time Estimates

Phase I

240 hrs. @ \$75.00

\$ 18,000

Phase II

100 hrs. @ \$75.00	7,500
100 hrs. @ 60.00	6,000
200 hrs. @ 45.00	9,000

Other Costs

Stack sampling 4 x 22,500	90,000
Reporting	4,000
Travel	<u>8,000</u>

\$ 142,500

Project Management (15%)	<u>21,375</u>
--------------------------	---------------

163,875

Administrative Overhead (10%)	<u>16,388</u>
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\$ 180,263

It is anticipated that this project element could be completed in one year.

Project Element 5

Objective

This project element will provide continuing information on the nature, experience in service and energy impact of all forms of gaseous emissions control equipment being developed worldwide, with particular emphasis on European technology.

Approach

The performer will be expected to maintain an up-to-date literature file on relevant published material which may be supplemented with information obtained at first hand from industry and research sources in Europe. The performer will be expected to make up to three visits to Britain, France and Germany as appropriate.

Annual reports will be presented verbally to the technical steering committee and in written form.

Performer

The performer will be a consultant familiar with both the brick industry and methods of kiln exhaust control. A record of performance in the skills of technology transfer will also be required.

Cost and Time Estimates

Travel - Three visits to Europe	\$ 10,500
Labour - 240 hrs. @ \$75.00	<u>18,000</u>
	28,500
Project Management (15%)	<u>4,275</u>
	32,775
Administrative Overhead (10%)	<u>3,278</u>
	\$ 36,053

This project element is expected to continue for the entire three-year period of the total program.

Project Element 6

Objectives

To transfer to the industry at large, the findings of the research project in the form of a summary report, including technical guidelines to the selection of appropriate energy efficient fluoride control technology.

Performers

Project manager of total program with input from consultants and performers of project elements 1 through 5.

Cost and Time Estimates

300 hrs. @ \$75.00	\$ 22,500
Travel	<u>4,000</u>
	\$ 26,500
Project Management (15%)	<u>3,975</u>
	\$ 30,475
Administrative Overhead (10%)	<u>3,048</u>
	\$ 33,528

It is estimated that this project element will require 0.5 year for completion.

ACKNOWLEDGEMENTS

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Clay Brick Association of Canada - Industry Task Force Members

Mr. J.F. Nicks	- Domtar Construction Materials, Domtar Inc.
Mr. J.P. Storer-Folt	- Canada Brick Ltd.
Mr. H. Penn	- Brampton Brick Ltd.

Clay Brick Association of Canada - Technical Steering Committee

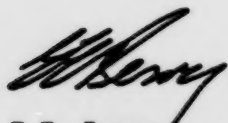
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Mr. M. Shayna	- I.X.L. Industries Ltd.

Clay Brick Association of Canada - Administration

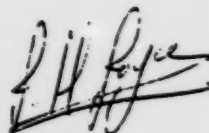
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Numéro**

2

FINAL REPORT

**FLUORIDE EMISSION CONTROL SYSTEMS AND THE ENERGY
EFFICIENCY OF TUNNEL KILNS - VOLUME II,
APPENDIX CONSISTING OF VISITATION NOTES AND OBSERVATIONS OF THE
CLAY BRICK ASSOCIATION OF CANADA INDUSTRIAL TASK FORCE**

by

The Clay Brick Association of Canada

Work on this project was conducted under the auspices of the
Canada Centre for Mineral and Energy Technology, Energy, Mines
and Resources, Canada.

DSS FILE NUMBER:	26SQ23440-2-9056
DSS CONTRACT SERIAL NUMBER:	OSQ82-00090
CANMET PROJECT NUMBER:	410104
CANMET SCIENTIFIC AUTHORITY:	Mr. K.E. Bell

DATE: January 28, 1983

This report should be cited as Contract Report No. OSQ82-00090

151 pp

MICROMEDIA

**Clay Brick Association
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This appendix consists of visitation notes taken by members of the C.B.A.C. Industrial Task Force during their visits to Europe and the U.S.A.

The Task Force members were:

	J.F. Nicks	of Domtar Construction Materials
	J. Storer-Folt	of the Canada Brick Company Ltd.
and	H. Penn	of Brampton Brick Ltd.

The Clay Brick Association of Canada

Industrial Task Force Visit to Europe;

Notes Taken by J.F. Nicks

PLACE: C. Keller GmbH Co. K.G.
Postfach 34
D-4530
Ibbenbueren-Laggenbeck
Germany

Telephone (05451) 85-0 Telex: 094522 Kellag-D

Present: J. P. Storer Folt } CBAC
J. F. Nicks }

Dr. Wolfgang Köther, Tech. Director, Kiln & Drier Div.,
Keller.

Date: Monday, October 18th.

GENERAL:

Dr. Köther was with the German Brick & Tile Institute on fluoride and energy research until a year ago; when he replaced Dr. Stahl who is now teaching in Munich.

Each raw material has its own characteristics, with fluoride levels of under 300 to over 1200 ppm. The average of German brick clays is 600 ppm F and 0.5% S. Calcium content and other factors alter the shale behaviour, not all of which are known at this time!

A material can have low F content and high release, or high F content and low release as a number of factors govern the F emission (or release) characteristics.

German standards in the clean air guide (T. A. Luft, 1974) of 30 mg/m³n F are currently in a state of change to an anticipated value of 10 mg/m³n. These regulations are enforced on a state basis with an amending formula that takes into account such things as background level in the district. This, in turn governs stack height for the particular volume emitted. (Believe stack height is a calculated value covered in the regulations).

Manufacturers who have converted to coal also face the added burden of particulate emission problems. In addition to the emission problems there are problems with ash build-up on cars and wine and over-flowing sand seals, etc.

The current air quality standards are all based on 3% CO₂ level. The German Engineering Society is objecting and are proposing an emission value based on kg air/kg product. Where a range of 3 to 5 is normal (3.9 is German average).

Two major R & D efforts have been completed as follows at the Brick & Tile Institute:

- 1) Tracked composition of gases through a production kiln on low CaCO₃ raw material.
- 2) Built a large laboratory muffle kiln to track F released as a function of time-temperature-atmosphere, etc., on a half brick.

RESULTS:

- 1) Emission rates are largely governed by the H₂O percentage in the kiln atmosphere in the temperature range 850-950 C, starting at 750 C.
- 2) The majority of release occurs before the hi-temp. soak and can be minimized if good fuel conservation is used. The greater the air leakage, the more fuel that is required and more H₂O is produced. The release stops at the onset of vitrification when the body seals up.
- 3) The more porous the body or thinner the section, the more the release. A frit added to the body such as 5% glass cullet reduces emissions. Addition of fly ash, sand, grog, etc., which opens up the body, increases release! CaCO₃ in the body generally reduces F release, (but not always). A surface engobe to form a skin below normal sintering temperature reduces emissions.
- 4) Soaking for removal of carbonaceous materials, should take place at 850 C, lower than normal, in order to go from 850 C to soak temperature as quickly as possible; as the time spent in the 750-900 C region also governs total F released.

- 5) Dry coal releases less H_2O in the kiln and can reduce emission by half (one case) from oil fired kiln.
- 6) The F cycle-readsorption of F occurs up to approx. 725 C. The F re-absorbed is re-emitted, however, at the higher temperature! Example: on a low $CaCO_3$ body showed no net F change. High $CaCO_3$ bodies are under study as they usually emit less of their F.

Many plants currently add materials to their body such as:

Coal
Styrene beads
Fly ash
Glass cullet
Sand

MISCELLANEOUS:

There are approx. 600 brick and tile plants in Germany. Government specifications for buildings dictate certain R values.

Absorption standards are:

Klinker brick absorbs less than 2% H_2O - 4 hr. boil.

Common brick absorbs from 4-10% H_2O - 4 hr. boil.

Block, tile absorbs plus 6% H_2O - 4 hr. boil.

General construction for residential in the north is 4½" face brick/1-2" air space/4-6" lightweight masonry including hollow horizontal cell block. In the south much of the work is stuccoed block, (clay or concrete). Cladding market is approx. 40% brick/30% block/30% sand lime. Brick is gaining share with variety and promotion. Current volume is very depressed with concern that many operations won't make it through the winter. Normal face brick pricing of approx. 600 DM/M is down as low as 400 DM/M. Majority of plants produce 150-250 t/day.

Fuel Prices

Gas - \$7.50 Cdn/Mcf (Northern Germany)
Bunker - \$5.00 C/l x 10^6 Btu (down from \$6.60 a year ago).
Coal - \$5.00 C/l x 10^6 Btu (\$65-\$75 U.S./tonne ground and dried).

EMISSION CONTROL TECHNIQUES:

Dr. Köther indicated that the following control techniques were used in Germany:

1) Dry Sorption System

Powdered lime (Ca(OH)_2) is injected directly into the flue gas stream; cooled if necessary, and the gas stream is cleaned by cloth filter (baghouse). Flue gas must be kept above the dew point to prevent condensation and provision must be made to by-pass the flue gases in the event of baghouse failure, temperature rise, etc. Firms involved are:

a) Heinrich Luhr - Staubtechnik
Enser Strasse 26
D-3060 Stadthagen
Germany (Postfach 360) Telefon - (05721) 708-0
Telex 97-22-81

b) Hellmich GmbH & Co K.G. - Holtkampweg 13
Postfach 1208
4983 Kirchlingern 3 (Quernheim)
Germany Telefon 05223-7059

2) Wet System - Condensation. Flue gases are passed through two heat exchangers in series; the first unit cools the gases to just above the dew point and the second unit condenses the gases. All energy recovered (water circuit) is used in dryers, etc., in the plant.

a) G.E.A.

3) Filter Bed System using corn-fraction limestone (CaCO_3) to absorb the SO_2 , SO_3 and F from the flue gases. May require down stream cloth filter system to control particulate emissions

a) see Hellmich GmbH.

PLANT VISIT:

Dr. Köther then drove us to see the GEA condensation installation at Carl Möller's paving brick plant.

PLACE: Carl Möller
Klinkerwerke-Hopstiner Strasse 65
D-4530 Ibbenburen 1

GENERAL:

Plant makes a number of sizes and colours of paving brick; 2 kilns (15 years old) on site but only one recently on stream. Kiln produces 140+/day solids. Use Bunker C at 700 Kcal/kg. Kiln is approximately 200' long x 10' wide set for index push; top and side fired in spring arch wide firing zone. Preheat zone is under-deck fired with 8 burners on each side, with atomizing unit firing into removable ignition rings approx 13" dia. x 36" long x 6" I.D. rings; severe coking problems were evident. Doors at dryers and kiln entrance were articulated and sealed against the end of kiln car.

Body is a mix of 4 very low lime clays, producing a very uniform colour range on a very well tailored product. A unique feature of the pavers is a 45° x 1/4" chamber on all edges (equipment well guarded).

Kiln exhaust at 210 C through underground flues from 4 side ports (each side). Control lies by tile dampers over the ports.

Standard paver sells for approximately 660 DM. Product is extruded, set on pallets, dried, unloaded and set on cars. Discharge is mechanical and loaded on pallets (Keller!).

Setting m/c operated one high to variations in setting patterns to vary density (10 high). Salt glazing (very light) with FeCl₂ additions - dry feed into a dutch oven!

GAS CLEANING SYSTEM AT CARL MÖLLER

It is a condenser system designed and installed by GEA. Möller claimed that the system cost approximately 1 million DM to install and the heat recovery system saved the equivalent of 3,000 l/day (oil). Other statistics noted were:

- Waste water from condensate treated and dumped to municipal system (Neutral).
- Waste solids are filter-pressured and filter cakes are not a disposal problem. Produce approx .5 kg/ton product produced.
- Stack volume is 500 m³/mm.
- Fuel consumption at plant is in order of 700 Kcal/kg
- Air to water heat exchangers.
- Hot water to dryers for drying.
- Emission reduced from 70 mg/m³ to less than 10 mg/m³.
- Power consumption 30 kw in winter, increases to 50 kw in summer when water requires a chiller to reduce temperature.
- Kiln exhaust 210C+, 1st heat exchanger exits at 120C+; second heat exchanger exits below 50 C and air must be re-heated to 50 C min.
- Present fuel costs:
 - Oil - 500 DM/tonne
 - Coal - 300 DM/tonne (processed)?!
- The exhaust gases from the condenser units are fed into a 70 m high masonry stack.
- Annual operating cost, say 40 kwh; chemicals for water treatment, disposal of filter cakes and labour \$30-50,000 plus maintenance.

NOTE:

The unit was not in operation during our visit. It was reported that one condenser unit had been recently replaced using corrosion resistant materials as the original unit had failed.

PLACE: Institut für Ziegelforschung Essen F.V.
AM Zelmthof 197-203
4300 Essen 13 Telefon 0201/59 00 17-19

PRESENT: J. Stoter-Folt } CBAC
 J. F. Nicks }
 Dipl. - Ing G. Schellback, Institut, Manager
 Dipl. - Chem N. Pauls Institut, Staff

TIME: Tuesday, October 19, 1982

GENERAL:

- 1) Discussed application of T. A. Luft. General target value for brick industry is 5 mg/m³n (n is normal sea level and 0°C.) at 3% CO₂ based on oil fired Bunker fuel with less than 2% S.
- Average tunnel kiln (German) output is approx. 100 t/24 hrs, fired 50/50 light/heavy oils.
- Average ratio kg air/kg product is 4 to 1 for brick industry with higher ratios for hollow tile and brick and refractories.
- F release from material is reduced by lower air/product ratios and energy efficiencies are improved. F release is principally temperature sensitive (i.e. generally major F release in 800-900 C range.
- Effect of calcium in raw material varies but generally high Ca materials produce emissions from trace to 15-18 mg/m³n while very low Ca content materials produce emissions from 50 to 100 mg/m³n. Important factor is that natural occurring Ca in materials are very fine; less than 2 microns.
- Institut has added fine CaCO₃ to low Ca materials but effect is not predictable i.e. some high and some low F release resulted.
- Institut believes natural Ca reaction is to bind F as CaF₂ when firing temperature is not over 1000-1050 C, whereas with CaCO₃ additions (10-50 microns!), body is porous and F release increases! (In Germany commercial CaCO₃ available in 60-90 micron range). Suggested that work be carried out with chalk additions or other very fine CaCO₃.

- Most favorable natural CaCO_3 range in materials is 12 to 25% with size less than 5 microns. (CaO equivalent 6-12% approx.).
- Among many other things, kiln operating efficiencies are affected by burner configurations and car loadings.

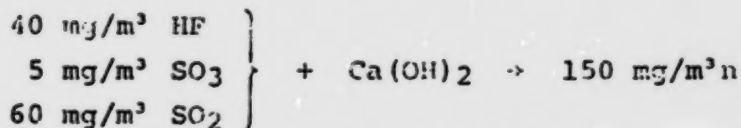
GAS CLEANING POSSIBILITIES:

In Germany there are 5-6 installations at brick plants based on dry absorption using fine ground CaO hydrated to increase internal surface areas for greatest activity. The basic reactions in the gas cleaning operation are:

- 1) $\text{Ca}(\text{OH})_2 + \text{SO}_2 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O}$ - 90% removal of SO_2
- 2) $\text{Ca}(\text{OH})_2 + \text{H}_2\text{F}_2 \rightarrow \text{CaF}_2 + 2\text{H}_2\text{O}$ - 90% removal of HF
- 3) $\text{Ca}(\text{OH})_2 + \text{SO}_3$ (from pyrites) $\rightarrow \text{CaSO}_3 + \text{H}_2\text{O}$ - 5-10% removal of SO_3

All these reactions are dependent on time, temperature and availability of $\text{Ca}(\text{OH})_2$. In normal operations 30-50% of the $\text{Ca}(\text{OH})_2$ is unreacted. Dust leaving the system to atmosphere must be less than 150 mg/m³n to meet present German emission regulations.

To achieve good reaction rates in dry absorption system (say 50 to 70% efficiency) gas velocity should be in the range 3 to 5 m/sec. and gas temperatures should be in 180-250 C range (higher is best). To meet dust regulations without cleaning, one can handle a gas stream with the following contaminants:



NOTE:

Reaction chamber should be in range of 10-20 m. long for 5-10 m/sec. velocities.

However, in dry systems dust cleaning is generally required and cyclones are totally unsatisfactory! The accepted method is by use of cloth filter systems with bag material carefully selected to meet service temperature requirements. Temperatures in system should be in order of:

180-250 C for injection of Ca(OH)_2	→	Through heat exchanger to capture energy.	→	Baghouse at 120 C ± depends on dew point principally!
--	---	---	---	---

Cost of Dry Sorption System for 150 t/24 hr. kiln.

Capital \$250,000 Cdn.

Operating Cost (annual) \$75,000

Includes: - Power

- Raw materials - Ca(OH)_2

- Disposal of Ca(OH)_2 unreacted plus calcium sulphite

Plus maintenance - 20%/yr. \$50,000

OTHER POSSIBILITIES FOR GAS CLEANING

1. Condenser System - see GEA system (one installed at Carl Möller near Ibbenbüren).
2. Passing kiln exhaust gas through a bed (or series of beds) of coarse calcium carbonate - not recommended!
3. Water spray with Ca(OH)_2 in suspension. Could control pH of water discharge to 7 approximately, and dump to municipal system. Solid disposal of CaSO_4 and CaF_2 (dewatered to cake) should be relative easy, i.e. no hazard!

Institut believes this would be a good route to investigate thoroughly.

4. Water Spray

i.e. Utah. There was one installation in Germany but it has been closed down for various reasons. Major drawbacks are 1) large volumes of water requires, 2) corrosion of spray tower (HF eats holes at random through materials), and 3) neutralization and/or treatment costs of the active sludge for disposal.

PLACE: Fraunhofer Institut Für Silicatiforschung
Neuner Platz 2
D-8700 Würzburg
Germany

PRESENT: J. Storer Folt
J. F. Nicks
Dr. Helmut Schmidt - Ass't Director
Gerhardt Tünker, - Mineralogist

TIME: Wednesday, October 20th

This is a private non-profit research institute. They do contract research for government, private industry and trade associations. They carried out the initial R & D for the Brick Industry (Essen) in F emission and continue work for the whitewares and glass industry. (fine ceramics).

They showed us their facilities and library which includes computer control and logging of S.E.M., electron microscopy, particle counting and characterization, X-ray fluorescence, spectroscopy, etc. In spite of the present business climate, the staff of Hfs has been kept busy and are planning the addition of pilot plant facilities. Their primary thrust is to improve processes to reduce waste losses and energy (i.e. applied R & D effort).

This has also been their approach to emission control - determine the mechanisms of F release and modify the process to minimize release as opposed to cleaning.

They reviewed the regulations and how the grandfather clause was applied.

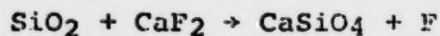
Each raw material must be tested for the amount and temperature of release.

FACTORS AFFECTING RELEASE:

- 1) Original F content in the raw material.
- 2) Total time over 1100 F or until sintering starts, particularly in dense brick i.e. 750-900 C.
- 3) Percent H₂O in kiln at point of emission. Temperature increases release $F + H_2O \rightarrow HF + OH$.

4) High percent HF in kiln atmosphere decreases release i.e. saturated condition.

5) If firing temperature is increased by SiO₂ addition, it opens body and increases release by reaction



6) The greater the permeability (porosity) the greater the F release.

7) The fluorine cycle in the kiln shows no net change in release (checked in Lab only) i.e. gain in F at low temperatures is equal to loss in F at higher temperatures.

8) F release is not affected by the clay mineral decomposition (dehydroxylation).

9) Natural CaCO₃ decreases release. Calcite added to open firing bodies increases release! Mechanisms are not well understood.

10) Increase in air-gas ratio increases release of F.

11) Change from gas to oil to coal decreases F release

12) Glass cullet did not help a body of 40% porosity fired at approx. 1100 C.

13) Engobes that seal the body help. Various experiments and results were discussed, particularly white-ware bodies.

14) The partial pressure of the F is much more rate-controlling than the pp of H₂O; and the role of CO₂ has not been studied!

A Dr. Herbst, Heimsoth (Kiln Co.) is looking into setting up a pilot kiln and plans to study recycling high F kiln atmosphere at point of release.

RAW MATERIALS

For a run of tests to check the fluorine profile:

1. Cost - 1500 DM/profile
2. Samples - $\frac{1}{2}$ brick dried
 - $\frac{1}{2}$ brick fired
3. Require time/temp curve, atmosphere, etc.
(full information on kiln operation)

[illegible]

3F analysis after firing

2 firing profiles re F release (with computer printouts).

OTHER INFORMATION FROM GERMAN BRICK INDUSTRY

Figure "A" - Shows test results from an operating tunnel kiln: temperature in the kiln, contents of SO_2 , SO_3 and F in mg/m^3 n. from kiln entrance to just past the firing zone (zones 4 thru 24). Note max. temperature in zone 22. F concentrations in the gas are highest from zone 15 thru 19.

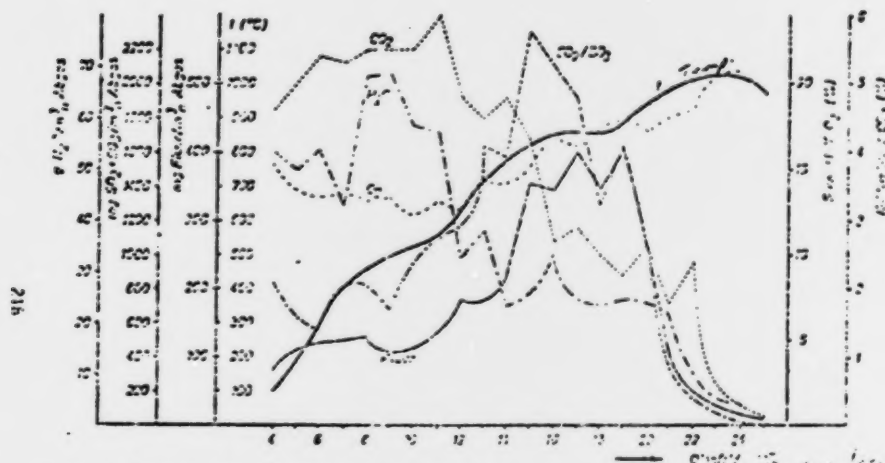


Figure A. Temperature and Gas Concentration in Tunnel Kiln.

Figure "B" - Shows the effect of H_2O content of the atmosphere in the firing. Fluorine emission increases with an increase in H_2O content.

Brick samples in A and B came from the same brick plant (material was almost lime free shaly clay).

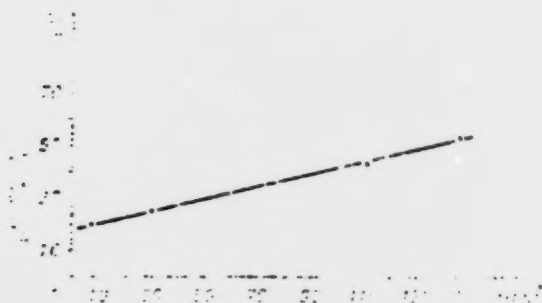


Figure "C" - Shows the Fluorine cycle in the kiln. This graph indicates the release of F between 800 and 1000 C (shaded area above the zero line) and the reabsorption of F between 300 and 800 C (shaded area below the zero line)

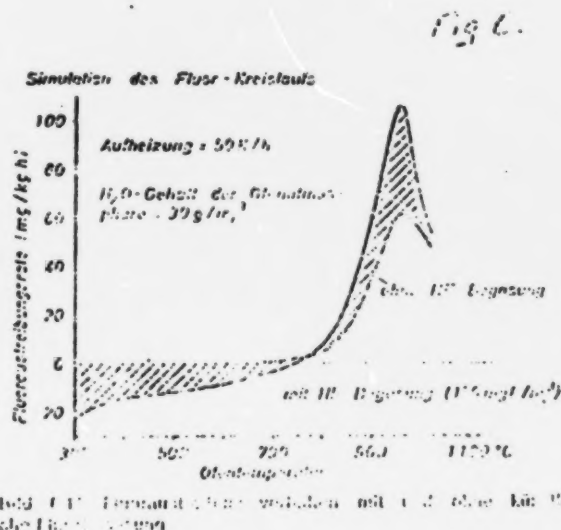


Figure "D" - Shows a typical F profile when firing with low temperature oxidation period, increasing temp. rapidly through the typical release zone and a short soak at finishing temperature - producing a relatively low total F release as indicated by the integral curve.



Figure "E" - Abstract from solution to a fluorine emission problem in stoneware production by G. Tunker and H. Schmidt of the Fraunhofer Institute for Silicate Research.

Solution to a Fluorine emission problem in stoneware production

Gerhard Tunker / Hebert Schmidt

Mitteilung aus dem Fraunhofer Institut für Siliciumforschung, Würzburg. Dedicate to Prof. Dr. H. Scholze zum 60. Geburtstag gewidmet

Report issued by the Fraunhofer Institut für Siliciumforschung, Würzburg. Dedicate to Prof. Dr. H. Scholze on the occasion of his 60th birthday

Durch Einsatz betrieblicher Maßnahmen konnte in einem durchvorgehenden Betrieb die Fluoremission im Rauchgas von 32,8 auf 14,3 mg F₂/Nm³ gesenkt werden. Dazu wurde in Laborversuchen der Einfluß von Glazur und Brennzeuf auf das Fluoremissionverhalten unter simulierten betrieblichen Bedingungen ermittelt und anhand der Ergebnisse eine Optimierung durchgeführt. Die Untersuchungen ergaben, daß durch die Verwendung einer Glazur mit etwas niedrigerer Aufschmelztemperatur und einer geringeren Brenndauer, bei der der Bereich der maximalen Fluoremission mit der maximal möglichen Aufheizgeschwindigkeit durchlaufen wird, die Senkung der Fluoremission unter Aufrechterhaltung der Produktqualität erreicht wurde.

The fluorine emission level in the flue gases of a stoneware production plant was reduced from 32.8 to 14.3 mg F₂/Nm³ through the introduction of certain process engineering measures. To find out the effects of glaze and firing schedule on the fluorine emission level were evaluated in laboratory experiments and a simulated field conditions and the results used to implement an optimization program. The investigation showed that the fluorine emission level can be reduced without loss in product quality by using a glaze with a somewhat lower melting temperature and a modified firing curve (in which the firing temperature range of maximum fluorine emission is passed through at the highest possible heating up rate).

Figure "F" - Graph from characterization of fluorine emissions by H. Schmidt and H. Scholze of the Silicate Institute. This indicates the thermo dynamic drive in the F release profile due to partial pressures of H₂O and HF. It is our understanding that when the drive

$$| -F + H_2O \rightleftharpoons | -OH + HF$$

is to the right and providing the HF is not removed from the system, F will not continue to be released. Objective is to reduce gas flow in this temperature zone.

4. Ergebnisse

Zur besseren Erläuterung der Wirkung der Fluorabspaltung, als Teil des Vorganges, ist thermodynamische Betrachtungen anzuführen. Bei der Überlegung, welche Parameter einflussreichend wirken können, ergibt sich, neben der Reaktion



der Einfluss von H₂O und HF in der Atmosphäre. Eine Abkühlung dieser Wirkung kann am Beispiel der hydrolytischen Zersetzung von CaF₂ auf Grund thermodynamischer Daten durch Berechnung der freien Enthalpien ΔG erfolgen. Bild 1

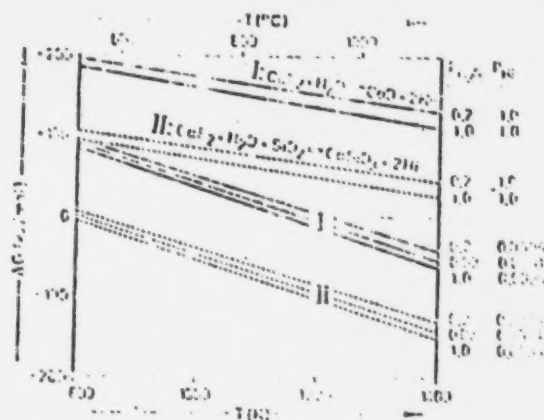


Bild 1. Die Abhängigkeit der Temperatur von Temperatur, H₂O und HF (Anteil an H₂O und SO₂ auf der Basis von CaF₂ und der freien Enthalpien ΔG (kJ/mol, H₂ mit SO₂)

PLACE: Ceramitec, Munich

DATE: Thursday, October 21, 1982

PRESENT: Hans Jakobides, Heinrich Luhr - Staubtechnik
J. F. Nicks - CBAC

GENERAL:

Heinrich Luhr are engineers, manufacturers and installers of flue cleaning systems (flat bag filters), Flat tube heat exchangers, condition drums, etc., for the removal of particulate and gaseous emissions. Luhr have installed systems at 12 ceramic plants (September 1982 listing) including at least four brick plants. I understand the installation at Oltmanns has been in operation for 2-3 years and a second installation is going on a Lingl kiln being installed at W. Roben.

DETAILS:

- Annual operating costs for W. Roben installation reported at 150,000 DM (say \$75,000/year) to clean 30,000 m³/hr. n. (approx. 175 ton/day brick plant equiv.)
- H. Jakobides estimated cost of a gas cleaning plant for Canadian brick operation exhausting 30,000 SCFM at 200-220 C made up of:
 - Additive system
 - Heat Exchanger to cool gases to approx 130 for entry to the bag house.
 - Conditioning drum
 - Bag house

Would be in order of 700,000 DM or \$350,000 Cdn.

Electrical load would be about 50 kw at \$21,000 annual electrical cost. And additive consumption would be in order of 4 kg Ca(OH)₂ per kg F. e.g.: at 1 kg/tonne product annual cost would be in order of:

90,000 tonnes product = 90,000 kg x \$40 tonne - \$3,600.00.

Annual operating cost would be in order of \$21,000 + 3,600 +
5,000 (disposal) + 35,000 (maintenance - 10%) - \$65,000/yr.

Referenzliste

10. 2. Ziegel - Keramik - Industrie, Brennöfen

Stand: September 1932

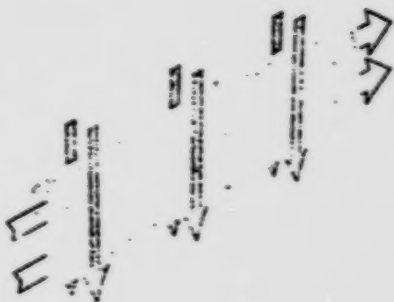


<u>Firma</u>	<u>Verwendungszwecke</u>	<u>Leistung</u>	
Agrob Wessel Servais AG 5300 Bonn 1 Werk Ismaning	Trockene Fluor-Abscheidung	6.400 Nm ³ /h	3744
× Berchthold GmbH. 8857 Wertingen	Trockene Fluor-Abscheidung	19.200 Nm ³ /h	3283
× Bott-Eder GmbH. 6909 Rauenberg 1	Trockene Fluor-Abscheidung Trockene Fluor-Abscheidung	10.500 Nm ³ /h 47.500 Nm ³ /h	3673 3918
Dachtal GmbH. 8472 Schwarzenfeld	Trockene Fluor-Abscheidung	10.400 Nm ³ /h	3007
Endlicher GmbH. 8600 Bamberg Werk Eggolsheim	Trockene Fluor-Abscheidung	2.260 Nm ³ /h	3728
Ljubecna 63001 Celje /Jugoslavien	Trockene Fluor-Abscheidung	20.000 Nm ³ /h	3553
Kaldewei 4730 Ahlen /Westf.	Entstaubung für Emailschmelze	12.000 Nm ³ /h	3674
× Oltmanns 3057 Neustadt /Hbg.	Trockene Fluor-Abscheidung	60.000 Nm ³ /h	3421
W. Rüben 2903 Bad Zwischenahn Werk Querenstede	<i>W. Rüben, Bad Zwischenahn</i> Trockene Fluor-Abscheidung	30.000 Nm ³ /h	3483
Villaroj & Bach 2400 Lübeck 12	Trockene Fluor-Abscheidung	41.000 Nm ³ /h	3611
Reinhold & Siedek 3000 Berlin	Entstaubung 3 Drehstrom-1-Öfen	20.000 Nm ³ /h	3721
Mundt & Kuhn 5230 Aachen 1	Entstaubung Fritttöfen Pulver-Entstaubung	19.000 Nm ³ /h 43.000 Nm ³ /h	4057

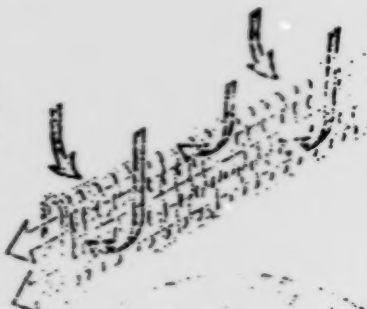
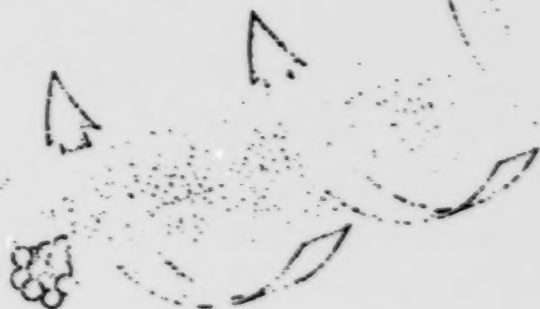
Clean Environment - Yes, Using cost saving Lühr Systems

5 Cleaning alternatives — 3 with compressed air injection — are available. Therefore the most economic cleaning system can be selected for a particular dust application.

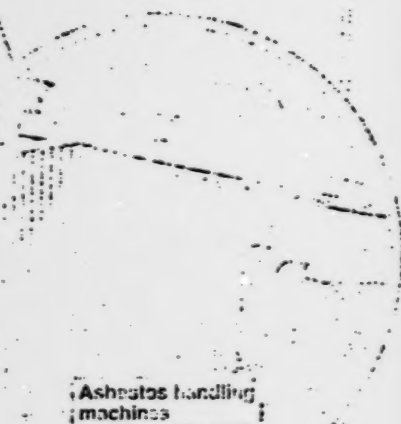
with smooth flat tubes, space saving. Automatic cleaning system is available — dependant upon application.



when fitted below heat exchanger and Filter, result in low Filter resistance, long cleaning cycles and high additive utilization factor.



Offer the advantages of high space utilization, positive location and sealing, and are easy to handle and exchange. Our Flat Bag system, when combined with the Lühr cleaning system, provide an economic package, resulting in low running costs and long bag life.



with gravimetric measuring has been developed by us and is now in operation.

1. Dust	50 mg/m ³	5 mg/m ³
2. Silica	5 mg/m ³	1 mg/m ³
3. Asbestos	100 mg/m ³	20 mg/m ³

if required

with gravimetric measuring has been developed by us and is now in operation.

PLACE: Ceramitec, Munich

DATE: Friday, October 22nd

PRESENT: Herr F. Hellmich, Hellmich GmbH & Co KG
J.F. Nicks - CBAC

GENERAL:

Our discussion was primarily carried out through an interpreter; although F. Hellmich has some basic knowledge of English. Basically there are three routes to consider in the control of emissions depending on a number of technical factors. They are:

- 1) Dry Absorption system, similar to the Lühr system, consisting of
 - a) Feeding or dosing the gas stream
 - b) Additive conditioning
 - c) Heat exchanger
 - and d) Cloth Filter - baghouse
- 2) Wet/Dry Absorption system. Basically similar to
 - 1) above but I believe a wet spray dosing system is employed.
- 3) Cascade Absorber This is a dry system employing sized CaCO_3 (3 to 7 mm) in an absorber tower. The principal is that the raw gas stream enters the tower and is required to make 2 passes through beds of CaCO_3 .
(Working on 4 pass tower) system consists of
 - a) Silo for CaCO_3 storage
 - b) Feeding system for continuous feed of CaCO_3
(4 tonne fill)
 - c) Cascade absorber
 - d) Spent CaCO_3 removal system, including recovery of unused CaCO_3 .

This sytem may require baghouse cleaning downstream to control particulate emissions.

COST OF CASCADE ABSORBER

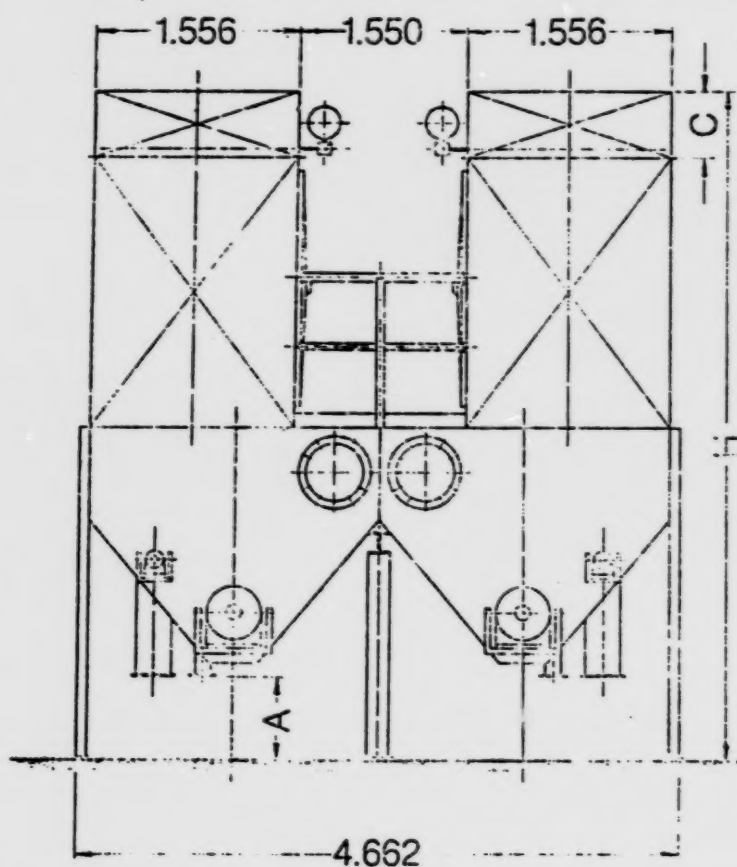
A budget estimate for a Cascade Absorber for a typical 250t/day plant exhausting 30-35,000 m³/hr n at 220-230 C with a F load at 2.5 Kg/hr would be in order of 400,000 DM ex works Germany. Electrical load would be in order of 55 kw and CaCO₃ consumption in order of 80 kg/day for stack loading of approximately 40 mg/m³. Annual operating cost estimated at 55-60,000 DM.

Mäntelungen
 Lüftungssysteme
 Filteranlagen
 Zentralstaubsauger
 Los- und Behälter
 und Ofenwagen
 Gefüge
 Sonderkonstruktionen
 Schal- u. Lärmbekämpfung

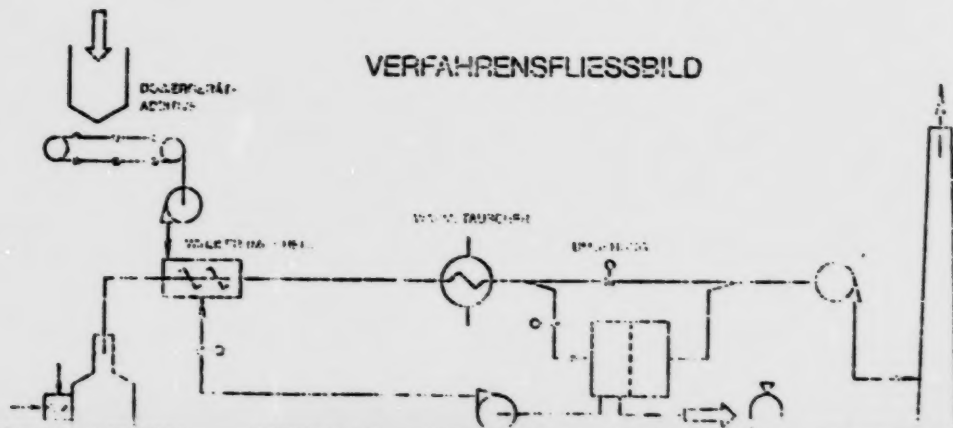
-Wilhelm Schleef-

Prof. F. Hellmich

HELLMICH GmbH & Co KG · Holzkampweg 13 · Postfach 1208
 4983 Kirchlangern 3 (Quernheim) · Telefon 05223/7059

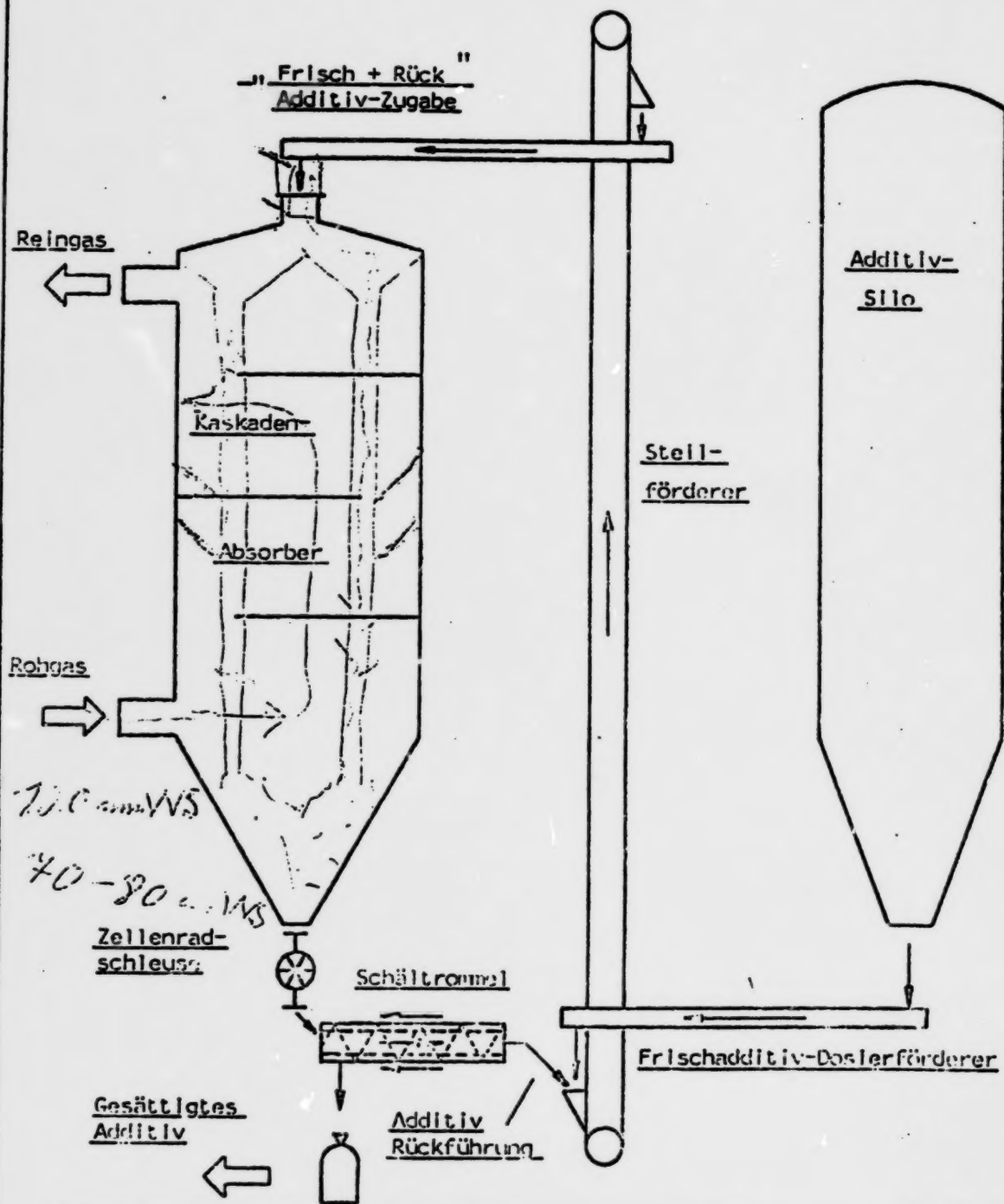


VERFAHRENSFLIESSBILD



KASKADEN-ABSORBER

„HF“ (DBGMa.)



PLACE: Ceramitec, Munich

DATE: Friday, October 22, 1982

PRESENT: H. D. Boke, Ing. Karl Walter & Co
J. Storer-Folt } CBAC
J. F. Nicks }

GENERAL:

Following our discussion with Dr's. W. Köther, H. Schmidt and others; we approached two kiln builders regarding kiln design as part of process modifications to reduce F emissions. We were referred first to Dr. Herbst of Heimsoth, kiln builders. Heimsoth indicated they were principally engaged in kilns for finer ceramics (stoneware, quarries, etc.) and referred us to Karl Walter & Co.

Karl Walter & Co. design and build kilns for heavy clay products, including brick, block and refractories, and in some instances provide for continuous or cyclical atmosphere control in the firing zone. At present the atmosphere control is being utilized principally for reduction firing in a number of TK's. Simply kiln gases are diverted around a section of the firing zone in order to isolate a zone for firing under reducing conditions. It would appear that the same basic technique could be utilized to isolate the zone where F emissions would normally be at a maximum, providing that the F cycle has been accurately determined; increase temperature rapidly with the minimum air required for the combustion of the fuel in order to keep air flows to a minimum (zero!) and allow the thermo dynamics of the system to control the F release to an absolute minimum.

SUMMARY

We expect Karl Walter & Co. to forward some basic information on a typical atmosphere control zone for a tunnel kiln.

WALTER

For these products

All types brick and hollow ware

All colours and glazes

Soft tile and floor tile

Roofing tiles

Ceiling tiles and slates

Manhole and other special tiles

Decorative and cover plates

Flower pots and garden ornaments

Manufacture of drainage and pipe lines

Also manufacture

of all types

of pipes

Concrete pipes

and all types

of sewer pipes

and all types

of drainage

and all types

of drainage

and all types

of drainage

and all types

of drainage

and all types

of drainage



H. D. BÖKE

ingenieur genl.

KARL WALTER & Co

- GmbH & Co KG -

Hilfenheimer Str. 413
6900 Mannheim 61

Tele 105 11187-1081 05
Tele 923650 wald

PLACE: London Brick Company Ltd.,
Technical & Research Department
Stewartby
Bedford, MK43 9LZ
England

Tel: Bedford (0234) 851851
Telex: 825643

DATE: Monday, October 25, 1982

PRESENT: R. (Roy) Beard, Director of R & D, London Brick
G. (Geof) K. Bowler, Chief R & D Officer, London Brick
J. F. Nicks, CBAC

GENERAL:

- 7,000 employees maximum; present complement 4,500.
- Production capacity 3,000 million (max.); operating at 1,600 million level in 1982. (40% of U.K. output).
- Major production is pressed, repressed flettons made from the fuel rich Oxford clay.
- Material is lower oxford clay from the Jurassic period, a marine deposit, illitic clay mineral with 5% organic content supplying 75% of fuel used in firing!
- Material contains approximately 1,000 Btu/lb; commences ignition at 600 C; reduction continues to 900 C; cooling air is injected over 900 to control maximum temperature; firing continues with 25-35 hr. soak at 950-100 C. Add 112 lb. of low grade coal per M brick (10,000 Btu/lb - high ash coal used).
- Output is shifting to facing brick from commons. Facing now runs approx. 2/3rds of production.
- Firing is in a modified Hoffman kiln of 34 chambers. Normal layout is 4 Hoffman's arranged around one 200' stack. One four-kiln unit produces 5 million brick/week. Plans now for new plants based on 4 kilns on a 400' stack.
- Company also involved in landfill operation with municipal refuse from London. Currently using methane recovered from the site to fire one Hoffman kiln!.

- Also have a couple of T.K. plants in other locations using clays at the plant site.
- Fluoride in lower Oxford clay in range of 600-800 ppm. Fired product shows F content from 275 to 1200 ppm indicating a gain in some samples. Overall there is a net loss with gaseous F emission from stacks.
- Stack emissions are SO₂, F and mercaptans with SO₂/F at ratio of 30/1. Major problems is odor from the organic combustibles in the clay. Note SO₃ is at very low levels. Basically depend on dispersion to meet environmental concerns.
- L.B. have studied emission control systems (approx. 30) and have built a number of pilot units to evaluate systems, i.e.
 - a) Incineration to reduce odor (cyclone) hi fuel cost
 - b) Catalytic incineration to reduce odor-catalyst failure
 - c) Wet scrubber (Peabody) using impingement plates in a tower - operating difficulties plus high operating cost.
 - d) Dry sorption system currently in process of construction

Note: Recommend an evaluation of the Luhr dry sorption at Oltman in Germany. (See Lingl and Luhr reference).

- Most desirable route is dispersion using higher chimneys.
- Clean air regulations in Britain basically do not set finite numbers on emission rates, etc. The H.M. Alkali and Clean Air Inspectorate has established air quality guidelines, testing and analytical procedures. When any significant change is to be carried out by a producer, (e.g. expansion, fuel change, new plant), the company must obtain planning approval from the local authority (county, major city) and at that time the approval is required for environmental concerns.

- L.B. has a history of over 20 years of monitoring air quality around their plant(s) of SO₂, SO₃, F and particulate.

Use 1) Lead dioxide candle for SO₂, SO₃

2) Lime candle for F

3) British Standard Deposit gauge for particulate

and 4) daily volumetric testing for SO₂ and smoke (by weight)/24 hr. sampling.

- L. B. C. average energy usage approx 7 therms/ton or about 1/3rd of total required. (2/3rd from clay).
- Indicated that time/temp. relationship, atmosphere, porosity, vitrification and CaO content are all factors which affect F release. Oxford clay contains 6-8% CaO.
- Lab employs approx. 30 people, 50% professional and technical.
- Lab functions include:
 - Chemical section for analytical - i.e. testing air quality (gaseous and particulate)
 - Geology section to core drill, map and control clay deposits on their extensive land holdings
 - Quality control and physical testing
 - Firing procedures, problems - (unique material)
 - Work related to refuse operation, leachate - hydrogeology, etc.
 - Product and field services assistance.

London Brick Company emissions

The gaseous effluent from Fletton kilns consists mainly of air and water vapour, as shown by the following table; with alongside it the comparable effluent from a typical domestic fire. —

Constituent	% by Volume	Typical domestic Open Fire
Air (Nitrogen and Oxygen)	93.94	72.79
Water Vapour	4.5	7.0
Carbon Dioxide	1.3	15.0
Carbon Monoxide	0.1	1.0
Hydrocarbons	0.1	4.0
Sulphur Dioxide	0.06	0.2
Fluoride	0.002	0.01
Mercaptans	0.002	trace

It is worth noting that 99.9% of emissions from Fletton chimneys are gaseous so the simplistic idea of 'filters in chimneys' is almost worthless. No more can gases be filtered from gases than beer from shandy.

There are three major potential pollutants in the kiln gases — sulphur dioxide, fluoride and mercaptans (the latter are organic sulphur compounds responsible for the characteristic odour of the effluent). All three are derived almost entirely from the Fletton clay — so that a change to, say, natural gas for kiln firing would have very little effect on the nature of the effluents.

The occurrence and properties of the three major pollutants are as follows:

(i) Sulphur dioxide

All substances can be classified as acidic (e.g. vinegar); neutral (e.g. water); or alkaline (e.g. washing soda). Sulphur dioxide is an acidic gas which has a sharp, dry smell

when present in high concentrations. It is formed when coal, coke, oil and many other materials are burned or heated, and because of its widespread occurrence in the atmosphere it is often used as an indicator of the general level of pollution. Sulphur dioxide has low toxicity and, in fact, is added to many foodstuffs as a preservative, e.g. dehydrated vegetables may contain a few thousand parts per million.

When high concentrations of sulphur dioxide and smoke are present together in the atmosphere, increased incidence of respiratory symptoms (e.g. bronchitis) may be expected. Other adverse effects which have been alleged include damage to vegetation and to buildings. Some local official reports of sulphur dioxide in the atmosphere have suggested, e.g. the suppression of some plant

diseases such as 'blackspot' on roses, and the supply of sulphur to plants as a nutrient.

The odour threshold of sulphur dioxide for most people is about one part per million (by volume) in the atmosphere — much higher than levels normally found in the brickworks area.

(ii) Fluorides

These are again acidic in nature, and are released from many industrial processes in which earth-won materials are heated, e.g. in the burning of coal, the firing of ceramic ware, the smelting of iron and aluminium and the manufacture of artificial fertilisers. Volcanic activity also releases fluoride into the atmosphere, and this was the cause of damage to grazing livestock in Iceland, where some of the classic early studies of fluorosis were conducted. Fluorosis is a condition caused by the accumulation of fluoride in animal bones, and continuous ingestion of high levels

Plate Fig. 4 — A

British Standard deposit gauge used to measure monthly rainfall and sleet deposited with it

may lead to skeletal damage. Once again, the concentration of the fluoride is the important factor, and in some areas (e.g. Bedford) fluoride is deliberately added to the public supply of drinking water in order to prevent dental caries, especially in the teeth of children. Fluoride occurs naturally in a wide range of materials including fish, bones and other tissues, especially tea

(iii) Mercaptans (and other organic sulphur compounds)

When Fletton bricks are fired during the 'curing' or 'drying' stage, the organic 'bad' gas which is partly distilled off is hydrogen sulphide and other hydrocarbons. Organic sulphur in the form of mercaptans is the main component of the gas, and is responsible for the powerful, offensive odour which is often noticed in the brickworks area.

Left Fig. 2 — Lead dioxide and lime 'candles' used for monthly assessments of sulphur dioxide and fluoride in the atmosphere

Right Fig. 3 — Close up of lead dioxide 'candle' located inside the louvered box

Left Fig. 5 — A general view of monitoring instruments in the Thermal Transmission Laboratory, Steamworthy



Left Fig. 6 — British Standard Daily Volumetric apparatus for measuring 24-hour mean smoke and sulphur dioxide levels (as used in the National Survey conducted by the Warren Spring Laboratory)

garlic, etc. and the familiar Flinton 'rock' is a cocktail of many odorants. Unfortunately, the human nose can detect mercaptans in the air at concentrations as low as one part in one thousand million! This is equivalent to one raindrop falling into Stewartby Swimming Pool. Hence, the very low concentrations can be discerned some miles from the source. Other industries emit similar odorants, which in these concentrations are not harmful, but certainly have nuisance value. An important chemical property of organic sulphur compounds is that they can be oxidized, e.g. by combustion, to form water vapour, carbon dioxide, and the much less malodorous sulphur dioxide.

Right Fig. 7 — A 'Flash' meter used to record 10-minute peak concentrations of sulphur dioxide in the atmosphere



The Monitoring

During 1959, a comprehensive monitoring programme was established by London Brick Company, mainly in the Marston Vale. Instruments giving integrated monthly readings of sulphur dioxide and fluoride were used, together with gauges to collect rainfall and deposited matter for analysis. Day readings of smoke and sulphur dioxide were measured by means of Daily Volumetric instruments (as used in the National Survey mentioned earlier). In addition to these routine tests, peak concentrations of sulphur dioxide were measured with mobile equipment, and atmospheric fluoride levels were determined in the vicinity of Stewartby Works. Some of the monitoring instruments are shown in Figs. 6 & 7.

Handled with these checks on the external environment, a large number of analyses were performed on kiln gases, flue gas and clinker in order to establish the levels of the various contaminants and to identify the part of the kiln system where they were released.

The results of this monitoring programme have, and are, supplied to H.M. Civil and Aeronautics, H.M. Inspectorate of Factories, the Statutory Authority for the Control of Air Pollution, and the

The Inspectorate themselves carried out hundreds of tests on all the Company's chimneys so that a comprehensive picture of the pollutant levels within the brick gas industry has been obtained. It was an apparent fact that levels of smoke were low compared to normal rural figures. Ground level concentrations of sulphur dioxide were equivalent to those in smokeless industrial areas, and significantly lower than the levels in large cities and areas of heavy industry (see Table 1, page 20). Smoke values are also shown in Table 2, and it is seen that these are very low in the brick works area. Although a wealth of information is available on brick works in general, little has been published on atmospheric fluoride levels in Britain because concentrations are very low. In fact, the Statutory Authority for the Control of Air Pollution in London, Portland

well below the levels at which adverse effects on human health may be expected.

More recently, emphasis has switched to the values of short term peak concentrations of pollutants, and London Brick installed SO₂ monitors at four sites within the Marston Vale. These measure ten minute mean concentrations, i.e. the four instruments record 210240 separate readings every year! Three of the SO₂ monitors are installed at sites where local Authorities operate Daily Volumetric apparatus. Results of London Brick's short-term peak measurements have been studied by Professor P. J. Lowther of the Medical Research Council, an acknowledged expert on the effects of air pollutants on health. The recently issued DoE Report 'Air Pollution in the Bedfordshire Bedfordshire' quotes Professor Lowther's findings:

"There is thus no evidence that concentrations of SO₂ in the area are ever high enough to produce any detectable effect on healthy people (using available studies) and none of the values, whether combined as annual or daily means, or as peaks within the day, are as extreme as those seen in past years in London."

Left Fig. 8 — A 'Flash' SO₂ monitor for continuous recording of atmospheric sulphur dioxide



The same DoE Report examined the atmospheric fluoride levels in the Marston Vale and stated "It is concluded that these emissions make at most a very small contribution to total loads and that they will have no effect on respiratory tract disease, dental disease or on the general health of the local community". Another section of the Report stated that absorption of fluoride from the atmosphere represented at most only about 4% of the daily human intake of fluoride.

A final word on fluoride. In the Marston Vale, the highest recorded peak level concentrations of sulphur dioxide were within the Marston Vale in 1959, and the highest recorded level of fluoride was in the Marston Vale in 1959. The highest recorded level of fluoride was in the Marston Vale in 1959.

SMOKE LEVELS IN THE MARSTON VALE

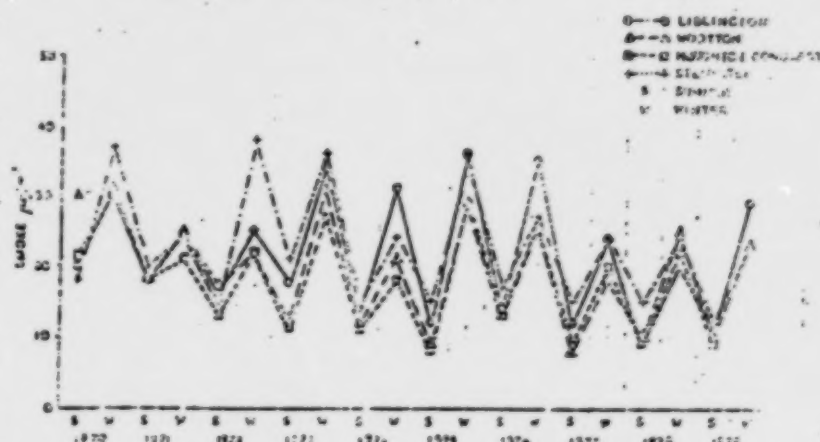


Fig. 9 — Trends in smoke levels measured in the Marston Vale over the past ten years

Wet scrubbing treatment

A major problem with any gas treatment process applied to the kiln is the large volume of gases at containing relatively low concentrations of pollutants. In 1972/73 research was therefore carried out on a separating 'third line' system, installed along one side of kiln 4 at Peabody Works. The underflame main flues were extended out beyond the wickets, and linked via ducting directly to a metal line running to a stack at the end of the kiln. By this means, the combustion gases from the cooling hot and main dryer chambers, which contain virtually all the pollutants, could be segregated from the drying gases, thus concentrating the pollutants into about one-third of the total volume.

Initially, the separated gases were monitored continuously for several days and nights to determine the concentrations of the various constituents and how they varied through the kiln cycle.

A number of gas treatment processes were then tested on a pilot scale, commencing with a thermal incineration plant burning oil, designed to heat the kiln gases to 870°C. in order to destroy the organic odours (see Figure 11). This was part of a success-

and actually increased sulphur dioxide output by over 20%. In view of these problems, a catalytic oxidation plant (see Figure 12) was hired from Germany — this was again designed to remove organic odour compounds but operated at a lower temperature (450°C). Unfortunately the catalyst was rapidly inactivated by the fluoride in the effluent.

Wet scrubbing processes have also been tested — the most successful being a Peabody double-alkali system (see Figure 13). This used an impingement-plate scrubber through which caustic soda was circulated, a bleed from the system being reacted with hydrated lime to regenerate the caustic soda and to precipitate out the reaction products (mainly sulphite, sulphate and fluoride). The end

Right Fig. 11 — An H.B.W. cyclone incinerator with high temperature fan, ducting and oil burning equipment

Left Fig. 12 — A 'Dacton' catalytic incineration pilot plant hired from Germany

ful — but of course complete was equivalent to an annual usage of 130,000 gallons for London Brick's kiln. Furthermore, the process did nothing to reduce fluoride emissions

product was a wet sludge which was malodorous and non-setting. Another unpleasant effect of the wet scrubbing process is that it cools the kiln gases and results in a 'condensing plant' effect. During the experiments the volume of the test area was observed with cold rain in winter, it was the necessary to heat the gases, which meant a large energy usage, in fact 6,500,000 gallons of oil per annum for a 10-million bricks per week Works. Another intractable problem in the disposal of the sludge — one of the proposed uses. With a wet scrubber 200,000 gallons per week, which, if typical, would form a significant and stable material for any further use. If treated as a liquid waste to be controlled by the Department of Environment, the sludge would be a special case if permitted by the Waste Disposal Authority.

The tests of the various gas treatment processes with kiln material was another major problem (see Figure 14) and it should be noted that wet scrubbing did not reduce odour emissions significantly, as noted by the Author's personal visits to these gas plants.

Finally, the wet scrubbing process

Left Fig. 10 — Trends in sulphur dioxide levels measured in the Marston Vale over the past ten years

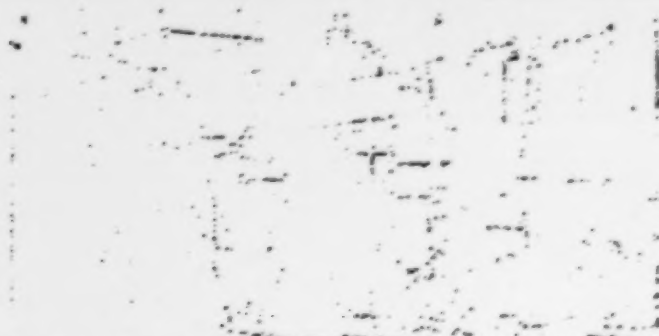


Fig. 13 - A Peabody impingement plate wet scrubber pilot plant with ancillary reaction and settling tanks

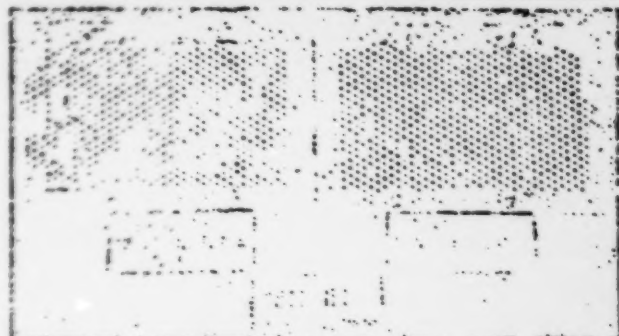


Fig. 14 - A view of build-up of limy materials on impingement plates from Peabody pilot scrubber

treatment processes have been carefully examined with the plant suppliers and H.M. Alkali Inspectorate but as the recently published DoE Report states: 'At the present time no single abatement technique exists to remove all the materials from the stack gases'.

Despite the difficulties, the research continues - London Brick has now signed a contract to hire a pilot-plant for a completely new gas-cleaning process designed to produce a dry waste-product in place of the extractable wet sludge. The plant is expected to be constructed by the end of 1990. It is worth noting that around one hundred different processes have been suggested for removing sulphur gases alone - the sheer number being a clear indication that no really satisfactory answer has yet been found. London Brick has a clearly-stated policy on gas treatment processes - we are willing to examine ANY PROCESS which has the remotest chance of solving the effluent problem.

However, the opinion of experts, including Cramer and Warner, the

eminent Consultants commissioned by the Bedfordshire County Council to examine the environmental aspects of Fletton brickmaking, is overwhelmingly to the effect that the tall chimneys proposed for the new Works should result in very low ground-level concentrations of sulphur dioxide and fluorides. Even odour will be substantially abated, and subject to continued monitoring. Cramer and Warner could see no justification for any gas treatment processes on the new kilns.

When considering the best policy to pursue, it is important to evaluate the total environmental impact of any scheme. As previously stated, many treatment processes demand high consumption of valuable energy sources; may lead to secondary pollution problems such as poisoning of the land; enter factory road traffic to and from Works; and consume valuable raw materials, such as lime, which has to be manufactured from chalk or limestone excavated in areas which are often National Parks. These seem high prices to pay for what can

only be a marginal improvement in the ground-level concentration of pollutants, even should a practicable process be developed.

Dispersion of chimney gases

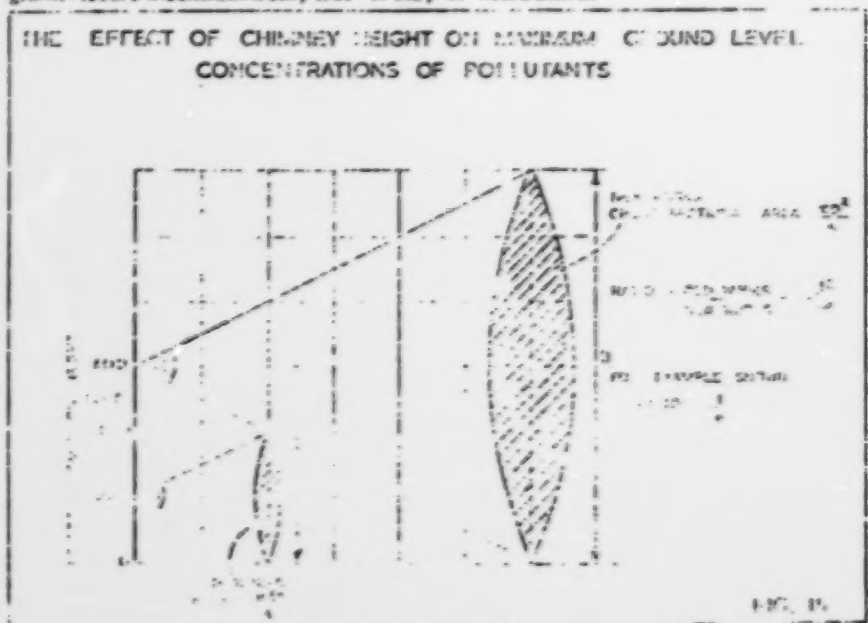
In view of misunderstandings and ill-informed statements regarding the likely effects of the taller chimneys planned for the new Works, this final section will try to explain this somewhat complicated subject of atmospheric dispersion.

To set the scene, the new Works planned by London Brick are replacements for the existing Stewarts, and Rickmans Works, a part of the packaging agreement reached with the Bedfordshire County Council, unused Works at Manton, Luton, and Coronation will be demolished, and a huge landscaping and replanting operation will be mounted to transform the Manton Vale. Six or eight chimneys will disappear, to be replaced by four tall stacks, two at each Works, with a height of 400 feet above normal ground level. This compares with an average height of less than 200 feet for existing chimneys. The reduction in the number of stacks will be achieved by linking four kilns and kilns for producing 14 million bricks per week to each one. This will have the effect of increasing the buoyancy of the gases (a large mass of hot gas cools more slowly than a smaller quantity of similar end-product). Together with the increased stack height, this results in an effective height of approximately three times that of the existing chimneys.

A simplified model of the efficient spreading of the chimney is obtained by considering an air containing cone travelling downwards, and expanding as the result of differences in density with the air. In ideal conditions the plume keeps rising until it is neutral in density to give an optimum diffusion effect. However, in real conditions the air in the plume is gradually cooled by the loss of heat to the surrounding air. As this occurs, the expansion rate of the gas will gradually be reduced and the plume will spread out more and more as it descends, while the ground-level concentration of pollutants increases.

The effect of the height of the chimney on the ground-level concentration of pollutants

Fig. 15 - Diagram showing the expanding cone concept of dilution of chimney gases. Concentration is proportional to the cross sectional area of the cone therefore new Works chimneys with three times the effective height of existing chimneys could lead to a maximum ground level concentration only 1/9th of the present maximum.



ple — the maximum ground level concentration is related to the stack height by an inverse square law. This means that since the effective height of the new chimneys is three times the height of existing stacks, the maximum ground-level concentration of pollutants will be reduced by a factor of nine — a value agreed by several groups of experts who have studied the proposals (see figure 15).

The other effect of increasing chimney heights is to move the point of maximum ground-level concentration further away from the source — but it should be clearly understood that this does not mean that areas further from the chimneys are receiving more pollutants. Far from it — all areas will benefit, but particularly those which are at present worst affected. The effect of chimney heights on ground-level concentrations is shown graphically in Figure 16.

Dispersion via tall chimneys is a successful technique which has been well proven by the C.E.G.B. which has to deal with fifty times the emissions of London Brick. Not only does it ensure good air quality, but it makes no demands on irreplaceable resources such as energy (fuel) and chemicals, nor does it create a secondary waste

Table 1. Sulphur dioxide and smoke levels at various sites, April 1977 — March 1978 taken from the National Survey 'The Investigation of Air Pollution' published by the Warren Spring Laboratory, Department of Industry (based on Daily Mean readings)

Site	Sulphur dioxide $\mu\text{g}/\text{m}^3$			Smoke $\mu\text{g}/\text{m}^3$		
	Summer	Winter	Year	Summer	Winter	Year
<i>Murston Vale</i>						
Husborne Crawley	9	17	13	59	68	63
Lidlington	12	24	18	68	65	67
Houghton Conquest	9	20	14	43	62	52
Stewartby*	15	24	19	55	34	44
Wootton	8	18	13	30	51	40
Cardington	7	13	10	42	57	50
<i>Other areas</i>						
Barnsley	33	107	69	79	141	109
Blackpool	13	42	27	26	55	40
Chelmsford	4	11	8	38	70	54
Chatterham	17	31	24	30	69	50
Derby	25	52	38	69	104	85
Hoddesdon	13	29	20	51	87	67
Leighton Buzzard	6	11	9	43	56	60
London (City)	19	37	28	85	162	123
162	123					
Loughborough	13	22	17	67	85	76
Paddington	24	38	31	81	142	110
St. Albans	15	32	23	33	75	57
Stony Stratford	9	23	16	28	55	41
Tottenham	15	37	23	53	114	83
Warwick	11	25	18	40	54	47
Westminster	20	30	25	104	180	141

* LBC monitoring site

problem. The only real criticism which has been levelled at this policy is the possible 'export' of sulphur dioxide to

Scandinavia where it may fall out as 'acid rain'. In fact, the main problem is one of geology — certain lake-systems (e.g. in Southern Norway) occur in areas where there is no limestone (which is alkaline) and therefore no capacity to neutralise the weak acids contributed by rain and the thawing of snow. To put the matter into perspective, about 50% of the U.K.'s sulphur dioxide emissions leave Britain's shores — and the U.K. 'exports' account for about 25% of the Scandinavian sulphur oxides. The total London Brick output of sulphur dioxide contributes about one quarter of one percent of the Scandinavian figure. Now Stewart's, and now Ridgmont will contribute less than half of this value, and in fact will emit slightly less pollutants than the existing Works. To suggest that the new Works would have any significant effect on Scandinavia is faintly ludicrous. Mr. Trevor Skeat, M.P. for Bedford tabled a Parliamentary Question on the likely effect of London Brick's new Works on Scandinavia. The written answer? 'Negligible'.

THE EFFECT OF CHIMNEY HEIGHT ON THE GROUND LEVEL CONCENTRATIONS OF POLLUTANTS

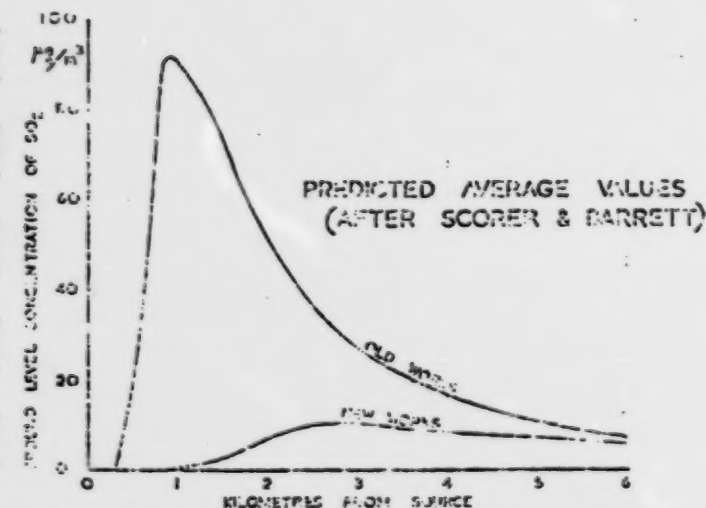


Fig. 16 — Calculated average ground level concentrations of sulphur dioxide at various distances from the source (old Works and new Works)

PLACE: The Brick Development Assoc.,
Woodside House
Winkfield, Windsor, Berkshire
England
SL4 2DX Telephone (0344) 851851

DATE: Tuesday, October 26, 1982

PRESENT: Rear Admiral A. (Tony) J. Monk CBE - Director General
T. (Terry) L. Knight, Head Prof. Services
John R. Harding, Materials Technologist

GENERAL:

- Brick shipments at 50% of 1975 levels with the construction industry very soft and more of the same predicted.
- BDA staff has been reduced by more than half - from high of 36 to present - 16 persons.
- Similarly BDA budget is 50% of 1978-79 level.
- Reported London Brick has a unique low cost operation and is in a good position. Vis-a-vis the present downturn in the building cycle.
- Looked at BDA publications and a few selected items will be forwarded courtesy of Mr. Edwards.
- BDA is not involved in quarrying, manufacturing and environmental problems in the industry. In those areas work has been carried out for the industry by the:
 - 1) British Ceramic Research Association
 - 2) The National Federation of Clay Industries
 - 3) Private organizations
- The basic approach to gaseous emissions is to reduce the source and dispersion by increase stack heights.

The Clay Brick Association of Canada

Industrial Task Force Visit to Europe;

Notes Taken by J. Storer-Folt

F - EMISSION SITUATION

OVERVIEW - SUMMARY

- I German regulations are enforced in such a way that older plants are allowed to operate without emission control except under the following two provisos:
 - 1) There are no substantiated complaints of damage to foliage or animals, or
 - 2) No substantial change is made to the process. This can be open to interpretation as a high emitter might be hit if he changes some burners, etc.
 - II All the countries are aware of the potential problem although the specifics of their approach may differ. There is a common theme, however, as follows:
 - 1) Where there is no damage, Governments appear to leave things alone. The cost/benefit relationship does not permit unnecessary application of regulations.
 - 2) If there is proven damage to people or property, changes are made to reduce emission levels.
 - III
 - 1) There may or may not be an energy penalty with pollution control equipment. It depends on the situation and the engineering of the solution used.
 - 2) The dry absorption system appears to be a reasonably practical solution in Germany and the wet system seems okay in France. The dry system would have to be modified for our climate with an energy penalty.
 - 3) Technical process adjustments can be made which may reduce fluoride emissions but each material must be tested and procedures evaluated. The adjustments may interfere with the rest of the process and could influence efficiency positively or negatively. The modifications may or may not bring the emission level down to the desired level.
 - 4) The thermochemistry of fluoride release has been investigated but more R&D is required for a complete understanding.
 - 5) Where a situation evolves that a significant reduction in emission is required, the following is recommended:
 - A) Develop and adjust the process as much as possible to reduce emissions.
 - B) If (A) still does not economically reduce emissions to a satisfactory level, the cost/benefits of process change versus control equipment add-on must be evaluated.
- Step (B) requires careful evaluation, as any add-on appears costly and risky from a practical operating standpoint.

C.T.T.B.
CENTRE TECHNIQUE DES TOILES ET BRIQUES

October 26, 1982 .

Claude Bardin
Chef des Laboratoires Duc.T.T.B.
200 Av du gl. DeGaulle, 92140 Clamart

There are no fluoride emission regulations in force in France at this time but some are expected at any time. No estimate of what the new regulations might be were speculated.

Up till the present the only circumstance that would cause any one to instal control equipment was if there had been litigation. There were only two plants with control equipment, one of which was Lambert and the other was in the south near Toulouse.

The highest fluoride of any clay that they had tested in France was .06%.

They have been following events in Germany and feel the regulations are impossible to meet. The German authorities turn the other way unless there have been complaints at which time they have the full power of the law behind them.

In the lab, I was shown two furnace setups for fluoride analysis. One was for checking total fluoride and the other was used to check emission under different atmosphere and time-temperature curves.

A copy of their test procedures were given but they were careful to point out that any outgassing was collected as opposed to an open fusion test.

CTTB is an organization of 70 people who operate as a service to the structural clay and roofing tile industry in the following areas:

- 1) Field service, customers complaints.
- 2) Lab services, tests, etc.
- 3) Training plant and field people.
- 4) Work on standards.

Financing is by a pay-for-test basis plus a 0.04% levy on shipments of all plants in the industry.

CERIC

18 Rue Royale

Paris

Claude Gomarín, R & D Directeur

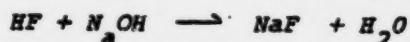
Pierre Rodriguez, Engineer.

October 27, 1982

Ceric have used Peabody-France for any plants or proposals that have come up regarding fluoride emission control. Peabody gained experience in handling Pechiney, France Al Smelters.

The Peabody process is the wet neutralization system as used at Lambert Ceramic.

For plants not able to discharge liquid pollutants, Peabody have proposed an add-on that would precipitate CaF_2 which would be filter pressed and disposed. This regenerates the NaOH for reuse, as follows:



In one proposal for a clay plant requiring emission control, Ceric conducted the following tests:

Time: $50^\circ\text{C}/\text{Hr}$ to Temp., + 4 Hr. Hold

	<u>Peak Temp.</u>	<u>Fin. Raw Matl.</u>	<u>Fin. Product</u>	<u>F Lost</u>	<u>% Lost</u>
L01	950°C	.109	.077	.032	29.4
	975	.109	.056	.053	48.6
8.9	1000	.109	.034	.065	59.6
→9.1	1025	.109	.032	.077	70.6
	1050	.109	.028	.081	74.3
	1075	.109	.023	.086	78.9

When extra CaCO_3 was added, results were as follows:

L01

16.82	1025	.091	.026	.065	71.4
	1050	.091	.024	.067	73.6
	1075	.091	.016	.075	82.4

These results made Ceric feel that emission control would be required. They felt that emission control on the limestone bodies by profiling the firing curve like the German R & D suggests would lead to other problems such as cracking. An example of this type of problem was presented as an actual plant case history.

A number of articles on fluoride emission control not already in hand were given (in German). They are not exactly the same as we had seen but cover similar ground. The main inference from these results are that F release in the kiln is controlled by the fluoride partial pressure in the kiln atmosphere.

Ceric is a French company manufacturing kilns and clay working equipment. They also construct complete plants and are by far the largest manufacturing company of this kind in France.

LAMBERT CERAMIC
Les Mureaux, Mr. Mansard, Tech. Mgr.

October 25, 1982

Saw roofing tile plant with wet scrubber system.

This plant adds salt to the clay mix at .05 to .1%. The reason given for the addition was that when the tile exit the tile slat drier at 90°F, they will absorb H_2O and crack in the air.

Composition:

LOI	-	8.35
SiO_2	-	58.00
Al_2O_3	-	22.00
Fe_2O_3	-	8.3
TiO_2	-	1.8
CaO	-	.82
MgO	-	.72
K_2O	-	.46
Na_2O	-	.14

Clay colour is yellow-brown.

Fired colour is weak red and porous.

Lack of natural flux in the material, might lead one to believe that the Na Cl performs a fluxing action as well as sealing up the fired surface.

Did not see the kilns but was told that kilns feeding stack are as follows:

1 kiln @ 90T/Day on 90 hr. sch.
3 kilns @ 30T/Day on 30 hr. sch.

Peak temperature is 1100°C.

Stack handles 60,000M³/Hr. with loading of .85 → 1 Mg/M³ F

.5% F in feed flue

The system is a wet scrubber tower built by Peabody in 1979 for the HCl emission.

1st system in 74 was for one kiln only. Was not shown and is at another part of the site.

Normal temperature of gasses from kiln exhaust fans is at $100 \rightarrow 120^{\circ}\text{C}$ with a maximum of 150°C .

After the cleanup the gasses go to a 30M stack.

In this system, 1 ton/day of NaOH is used. It is stored outside in a fiberglass tank. The feeder ducts from the kilns, the reactor vessel and stack were made of resin-bonded fiberglass.

Vessel was approx. 8.5' square x 12' high.

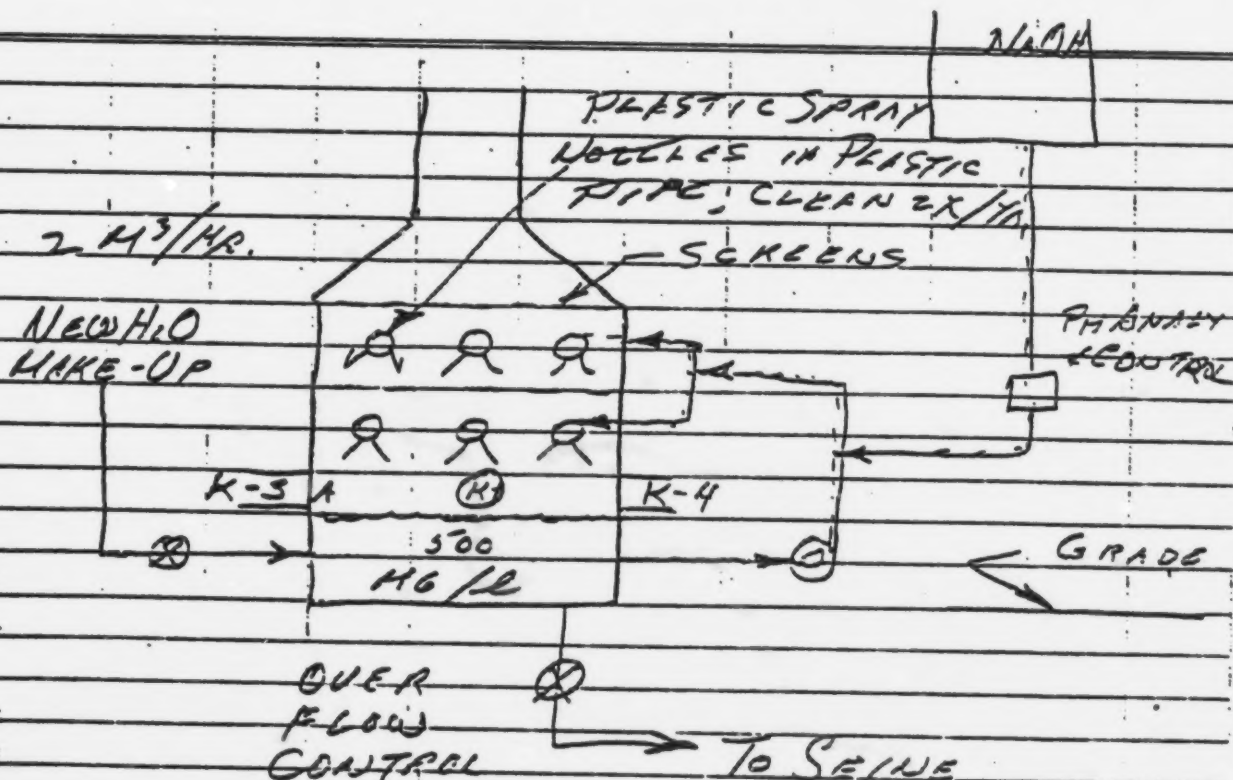
Cleaned gasses contain 18 ppmF.

Circulates $2\text{M}^3/\text{Min}$.

Ex. 6 x .5" Nozzles.

New fluoride regulations for France are thought to be $20\text{Mg}/\text{M}^3$.

Plant was concerned because new regulations for water discharge are just coming into force.

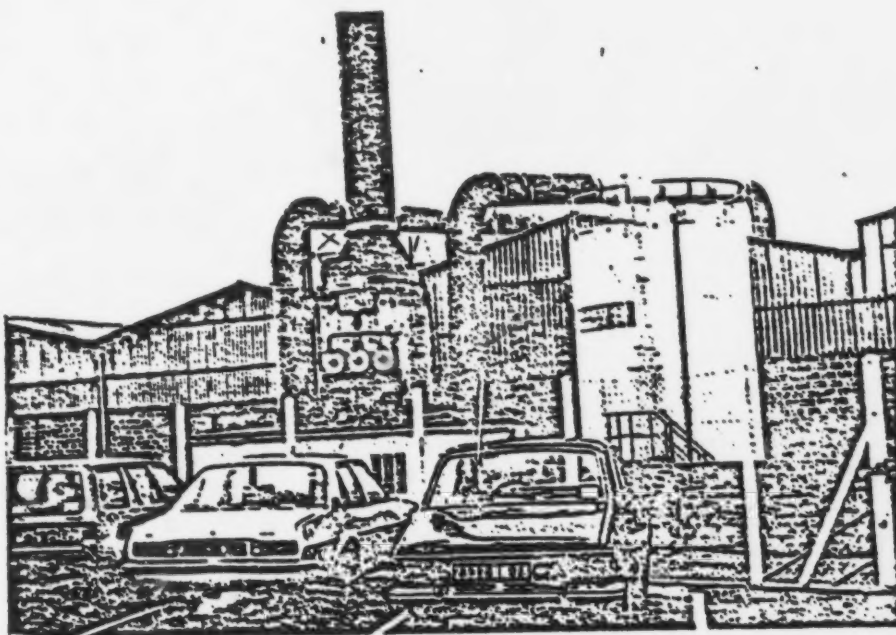


Capital Cost - \$250-300,000. U.S.

A = Additional H_2O spray if temperature gets too high.

Solids of 500 Mg/l in bottom of vessel and they are looking into wet evaporator condensate systems because of the new regulations. This would give them NaCl & NaF & a chemical plant to boot.

The present system looks neat and clean and lo maintenance. The whole system was twinned for standby and cleaning. See photos.



BRITISH CERAMIC RESEARCH ASSOCIATION
Mellorgreen Labs, Stoke-on-Trent
Mr. R. Ford

October 29, 1982.

There are no fluoride emission regulations in U.K. at the present time.

Fluorine problems have occurred in two specific situations.

- 1) An aluminum shelter in Scotland was placed under Government orders to clean up a number of years ago.
- 2) London Brick Co. has closed one or more older plants and raised stack heights on others. Their problem is one of concentration as a standard LBC plant produces 250MM out of 3.6 billion production total. This gives a lot of emission from one location and thus can be a problem. Another point is that a number of their plants are located inside old clay or coal pits. This makes for difficult dispersion factors without enormous stacks. In these cases stack emissions would be rolling up to neighbouring property.

Neither the French, German or British Research Associations are aware of any fluoride emission regulations in the Scandinavian or Benelux countries.

Because of the concentration of brick tile and whiteware plants in the Stoke-on-Trent area, the Government was concerned about the influence of the background and levels on surrounding agriculture due to the soil uptake. A farm was purchased and cattle monitored. Results of these tests have been reported but R. Ford will send us a copy.

Mr. Ford was not aware of any other abatement situations in the brick and tile industry, as it would appear that Government and industry are prepared to let sleeping dogs lie.

Almost 100% of British structural clay is fired with gas, creating no particulate emission. LBC uses raw material with 4-8% carbon and is self firing.

Much R & D is under way at present to save fuel by adding coal washings and other hi carbon shales to the mixes plus sawdust or grog to open the body.

Approvals for new plants are by local planning boards and an applicant would have to prove that there would be no damage to the environment.

The Clay Brick Association of Canada

Industrial Task Force Visit to U.S.A.

Notes Taken by H. Penn

C.B.A.C. FLUORIDE COMMITTEE

INDUSTRY TASK FORCE

VISITATIONS

- A. Interstate Brick & Ceramic Tile
West Jordan, Utah
- B. Globe Refractories Inc.,
Newell, West Virginia

by

Howard Penn
Brampton Brick Limited

October 29, 1982.

A. Interstate Brick & Ceramic Tile
West Jordan, Utah.

October 13, 1982.

Contacts:

1. Mr. Harvey Cahoon, V.P. Operations
2. Mr. Vic Ingraham, Plant Manager
3. Mr. Richard Lowrie, R & D Manager

INTERSTATE BRICK & CERAMIC TILE CO.

WEST JORDAN, UTAH

Interstate Brick & Ceramic Tile was founded by John P. Cahoon (grandfather of current president Harold P. Cahoon) in 1878 with a simple field Kiln. The business incorporated in 1891 as Salt Lake Pressed Brick Co. and became Interstate Brick Co. in 1936. In 1971, the firm merged with Entrada Industries, a subsidiary of Mountain Fuel Supply Co. In 1972, Interstate Brick moved to it's present West Jordan site, situated approximately 80 km south of Salt Lake City. There are 4 brick manufacturing plants and one ceramic tile plant operating on this site. The combined annual capacity of the 4 brick plants is 190 million brick equivalents. The capacity of the tile plant is 1 million tiles per year.

A variety of products are manufactured at the Interstate, which include the Basic shapes (Standards, Modulares, Normans, Jumbo), Atlas brick, Special shapes (Bullnose, Angles) chimney brick and pavers. (Flgs) Each product conforms to a designated ASTM regulation (Tables).

The four brick plants each have one tunnel kiln with one stack. The tile plant has two periodic kilns with a single stack. Diagram outlines the process flow of all 5 plants.

Interstate developed a wet scrubber system during the 1960's and has refined it's design over a 20 year period. A 1978 EPA test report indicate a fluoride removal efficiency of 97%.

The 4 pre-1981 calcium carbonate wet scrubbers are installed in 60 foot (18m; vertical reinforced brick stacks with effluent recirculation through inground reinforced concrete tanks. E.P.A. test data report relatively high concentrations of fluoride and sulphur in the clay; with very little retained in the fired brick: (2)

The inner measurements of the stacks are approximately 12 sq. ft. At the bottom there is a lead plate, approximately 1/8" thick, that creates a water tight barrier. The lead plate runs through the walls of the scrubber and is bent at the edges, to catch any leakage that is forced through the scrubber walls. The released water is channeled around the outside of the scrubber and is run off into the settling pond. Access entrances are installed at the bottom of the scrubber for inspection and cleaning purposes.

The scrubber is packed with polypropylene plate, approximately 6" square, that hang from 1/2" diameter polypropylene ropes. The plates are approximately 1/8" thick and are pierced with several holes. The plates are pulled up on the ropes with a 1 foot spacing and are held in place by a short piece of round plastic rod which is pushed through the rope. The plate rests horizontally on the rod. The ropes are in appropriate steel construction, that is built-in 4 sections that are on the scrubber stack. The ropes have a clearance of 1 foot on the framing.

The steel frame consists of 4 sections, so that the frame can be easily spaced together with the appropriate ropes and plates, and actually, in the middle of a mobile crane. The frame is protected with epoxy paint to prevent corrosion.

When the ropes are brought against the steel frame, at the top of the scrubber, they hang 30 feet down.

A constant stream of water, neutralized with calcium carbonate, is pumped up to the stack (with use of a Gould pump; metal parts are chrome-nickel plated; through polyvinylchloride-pipes. It is then sprayed in large drops into a plastic-sealed labyrinth of ropes and plates.

A small ditch system was installed on the scrubber to ensure that a smaller water stream flows into the stack when the pump breaks down or in the event of a power failure. This is very important, since the plastic scaler melts very quickly when it is exposed to non-cooled flue gases.

It has been established that a high calcium lime must be used and not dolomite lime, which is readily available. The magnesium in the dolomite lime does not react and consequently, reduces the effectiveness of the lime.

When the lime water falls, it comes in contact with the flue gases, resulting in the formation of calcium fluoride and calcium sulphate. These materials are rinsed into the storage pond and settle at the bottom. The water is then neutralized and once again pumped up to the scrubber. Other than evaporation, this is an enclosed circulation system.

The storage pond is held at a pH seven, in that the water is tested with pH indicator paper and then the speed of the screw conveyor, with which the lime is conducted into the pond, is set.

The two major problems encountered with the scrubber system are corrosion and obstruction. Interstate has not been able to find an inexpensive metal which can be used in the scrubber without extensive protection by way of painting or observation. The fluoride-sulphur combination is very destructive for almost everything but plastic.

The problem of obstruction appears when calcium fluoride and calcium sulphate builds up in the pipes, on the ropes and plates and even on the walls of the scrubber. At one time Interstate sealed the scrubber with brick grating, but then went to plastic sealing

1c.

since the grating plugged and the flue gases could not pass.

There is a man assigned to maintain the system. Approximately, 8 hours per week are spent cleaning the pipes, clearing the drain hole, testing the regularity of lime addition and overseeing the general operation.

Every three or four months the operator cleans the settling ponds out. The sediment is dumped into a pile on the plant property. At one time the sediment was sold as low valued river spar.

The scrubber is a drop system, that requires a small amount of energy and low pressure.

Operating data for the scrubber systems on Plant 1, 2, and 3 are as follows:

Flue Gas Volume - 22,000 ft³/min (37,000m³/hr)

Flue Gas Temp. - 450°F (230°C)

Capital Cost (1971) - \$40,000 U.S.

Water Quantities - 2 IGPM (0.5m³/hr)

Lime Quantities - 750 lbs/day (340 kg/day)

Energy Consumption - 15 kw

Pressure Loss in - 1 inch H₂O (2.5 g/cm²)
Scrubber

The following scrubber efficiency results are obtained on a continuing long term basis:

Fluoride removal - 95-99%

Sulphur removal - 75-80%

The following emissions are reached:

Fluoride emission - 7.0 mg/m³ (0.003 grains/m³)

Sulphur emission - 0.11 g/m³ (0.046 grains/m³)

For plant No. 3 the maximum fly ash emission is 23 mg/m³ (0.01 grains/ft³)

2.

	<u>Fluoride</u>		<u>Sulphur</u>	
	ppm	%	ppm	%
Green Brick	549.6	0.055	1030	0.103
Fired Brick	23.2	0.002	190	0.019
% Retained		4.2%		18.5%

A 1975 EPA report on Interstate stack emissions was: 1)

	<u>ppm</u>	<u>mg/m³</u>
SO ₂	135	359
SO ₃	12	39.9
F	205	169

A 1978 EPA report demonstrates the efficiency of one of the pre-1981 Wet Scrubbers:

Stack Height - 60 feet (18.3m)

Exhaust Rate - 30,000 cfm (50,970 m³/hr)

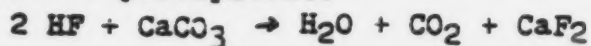
Exhaust Temp - 400°F (204°C)

Throughput - 10 tons/hr (9.1 tonnes/hr).

Fluoride Emission (mg/m³)

<u>Test</u>	<u>Pre-Scrubber</u>	<u>Post-Scrubber</u>	<u>% Removed</u>
1	28.4	0.81	97.15
2	63	1.52	97.6

The wet scrubber for Plant No. 4 (1981) is similar in principal to the 4 existing vertical units. Exhaust gas flows through a plastic packing, suspended on polypropylene ropes. Calcium carbonate solution (Quick-lime) is sprayed into the packing and pollutants are washed from the gas. Physical washing removes particulate matter and chemical scrubbing removes the problem elements. Hydrogen fluoride gas combines with the calcium carbonate to form water, carbon dioxide and calcium fluoride, an insoluble precipitate:



3.

The principal is similar to the Luhr and Helmich systems, which use calcium carbonate powder, followed by bag filtration. The Interstate system, however, combines this efficiency with simplicity and economy.

The wet scrubber and 80 foot stack for Plant No. 4 were constructed for \$125,000 US (\$155,000 CDN). The scrubber structure is a horizontal brick masonry building, 10 ft. (3.05m) in height. The configuration of the scrubber, stack, calcium silo and recycling pond are shown in diagram.

Two 90,000 cfm (2550 m³/min) kiln exhaust ducts exit below the Brick Plant floor and enter a 5 ft x 5 ft (1.53 x 1.53m) above inlet duct. Based upon 180,000 cfm (5100 m³/min, exhaust rate and a 25 ft² (2.32 m²) cross sectional area, the inlet duct velocity would be 7200 ft/ min (2195 m/min).

The 400°F (204°C) exhaust enters the horizontal scrubber structure. This structure, with an 8 inch (20 cm) divider wall has the following dimensions.

Length	38 ft (11.6m)
Width	20 ft (6.1m)
Height	10 ft (3.05)
Cross-Section	100 sq ft (9.29m ²)
Exhaust Velocity @180,000 cfm (5100 m ³ /min)	1800 ft/min (549 m/min)
Effective Length	78 ft (23.9m)
Contact Time	2.6 sec.
CaCO ₃ Solution Flow Rate	1500 IGPM (6.8m ³ /min, (240 ft ³ /min) (6800 l/min)
Exhaust: CaCO ₃ sol'n	750 : 1
Ropes @12" C/C (30 cm c/c)	544

The packing consists of polypropylene ropes attached to the ceiling at 12 inch (30 cm) centres. The ropes are pinned at 6 inch (15 cm) vertical intervals to support the 6 x 6 in. (15 x 15 cm) plastic plates. The polypropylene deteriorates at about 130°C, however, the scrubber inlet spray is sufficient to cool the exhaust gas to a tolerable temperature range for the packing.

Interstate manufactures a special chimney brick, which is used to line the ducts, scrubber and chimney. The scrubber and chimney exterior is face brick. The scrubber entry door is sealed with fire brick which is removed for annual maintenance. The scrubber floor is 12 in. (30 cm) lower than the inlet duct and chimney; and the floor slopes away from the stack through a 12 in. (30 cm) PVC effluent pipe to the 50 x 70 ft (15.25 x 21.4m) pond. The effluent pipe has a cutout for sampling; CaCO_3 addition; and daily pH testing with litmus paper.

The pond is 10 feet (3m) deep with a 4:1 slope at one end for cleaning. Cleaning is required when the CaF and particulate sludge accumulation is from 4 to 5 ft (1.2 to 1.5m). Two ponds can be alternated. The sludge is dumped into the quarry. The new plant, No. 4, has one pond. The system will be shut down every 12 months for cleaning.

The CaCO_3 storage silo is prefabricated steel, about 12 ft. (3.66m) x 30 ft (9m). The monthly consumption for Plant No. 4 is approximately 20 tons of CaCO_3 .

The stack is 13 x 13 ft (4 x 4 m) outside and 11 x 11 ft. inside (3.4 x 3.4m) with a cross sectional area of 121 ft² (11.2m²) and an exhaust rate of 180,000 cfm (5100m³/hr). The exhaust velocity is about 25 ft/sec (7.6m/sec).

5.

(Coal-fired Keller Kiln) also serves to remove the fly ash particulate from the exhaust gases, which, in turn are deposited into the settling p

PLANT NO. 4 DATA - SCRUBBER

1. Throughput - 680,000 lbs/day (340 tons/day).
2. CaF/sludge deposition rate - 20 tons/month.
3. CaCO₃ feed - mechanical using a screw feeder.
4. Type & Number of Spray Sozzles - 25 stainless steel #316 flat plate.
5. Plastic Plate material - polyethylene.
6. Plate - Vertical Spacing - 6"

INTERSTATE BRICK & CERAMIC TILE

WET SCRUBBER OPERATIVE COSTS

PLANT NO. 4

The operating costs listed below are based on 18 cars per day (212,292 brick equivalents), 52 weeks per year.

Capital cost \$125,000 (U.S.) 1981.

	\$U.S.
1. Supplies, lime, etc.	12,300
2. Maintenance (cleaning)	9,125
3. Power	4,420
4. Water	2,100
5. Depreciation	19,600
6. Tax	<u>13,600</u>
TOTAL	<u>⁶¹ ~~\$42~~,145</u>

INTERSTATE BRICK & CERAMIC TILE CO.

QUESTIONNAIRE

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5 - Tile
1. Kiln Type	Tunnel	Tunnel	Tunnel	Tunnel	Shuttle (2)
2. Manufacturer	Pullman Swindell	Pullman Swindell	Keller	Harrop	Bickley Pullman Swindell
3. Age	1971	1971	1979	1981	1972
4. Capacity SBE/yr	45.5 million	45.5 million	51.0 million	65.5 million	1 million
5. Size	400' (42 cars)	400' (42 cars)	400' (35 cars)	509' (46.5 cars)	
6. Energy Consumption BTU/#	1650	1650	1100	1000	
7. Maximum Firing Temp	2240°F	2240°F	2080°F	2080°F	
8. Total hrs thru Kiln	50.4	50.4	60	50.7	
9. Firing System	Under-deck Continuous	Under-deck Continuous	Top-fired Continuous	Top-fired Continuous	
10. Fuel	Natural Gas	Natural Gas	Coal	Natural Gas	Natural Gas
11. Btu/unit (fuel)	960 Btu/ft ³	960 Btu/ft ³	14,000 Btu/lb Utah Bituminous Ash - 10% Sulphur 4-5%	960 btu /ft ³	960 Btu/ft ³
12. Emission of F tons/yr	0.7	1.2	0.4	1.3	0.1

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
13. Emission of S tons/yr	1.0	1.6	4.2	1.7	0.2
14. Temp of Exhaust Pre-Scrubber	300°-400°F	300-400°F	300-400°F	300-400°F	300-400°F
Post-Scrubber	120°F	120°F	120°F	120°F	120°F
15. Volume of Exhaust Gases CFM	25,000	25,000	32,000	57,000	15,000

INTERSTATE BRICK & CERAMIC TILE

RAW MATERIAL

18 raw materials used to provide 13 mixes

Clay - 45 miles south; Wyoming

Shale - 130 miles north.

CLAY - Illitic

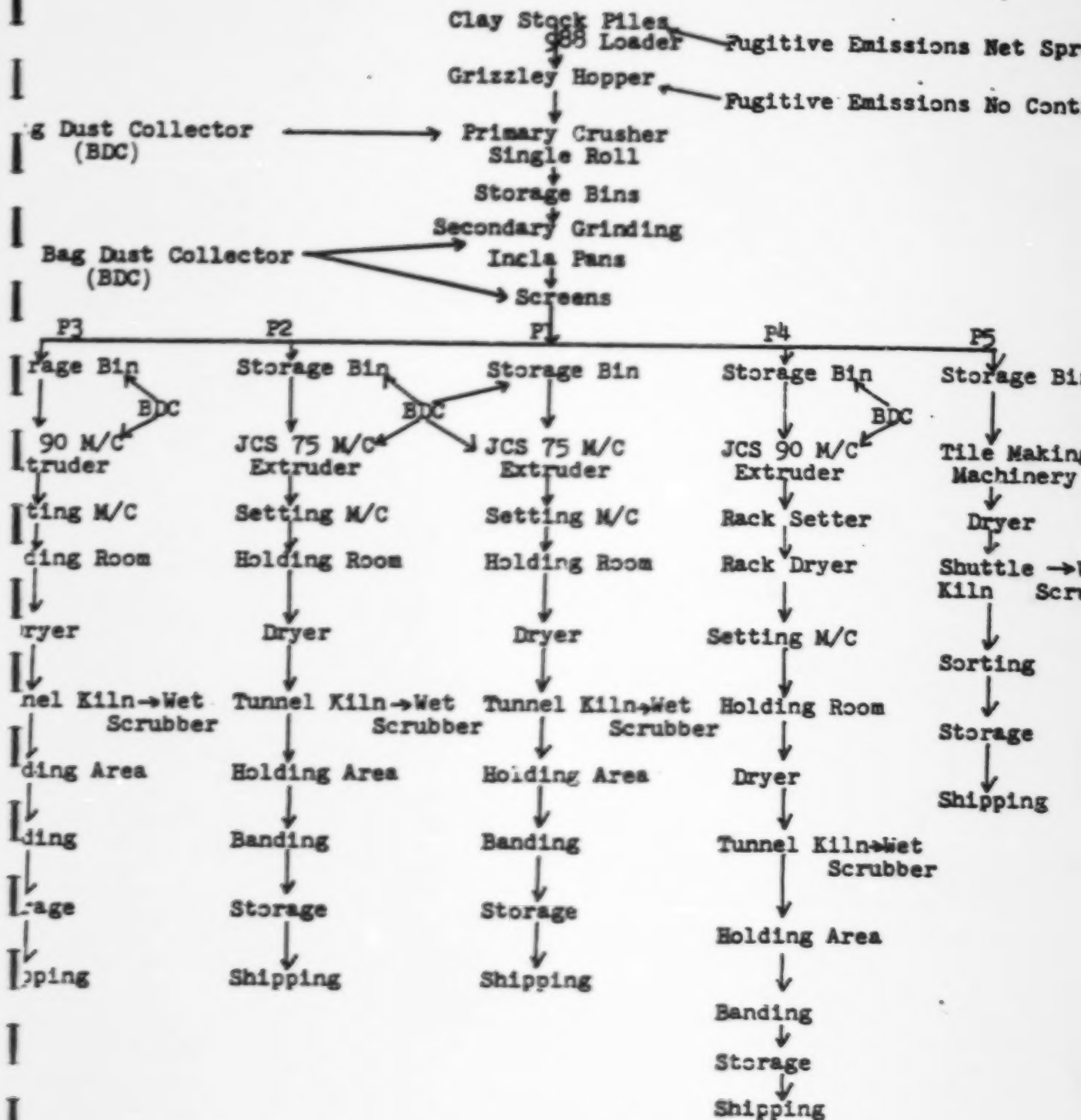
Chemical Analysis

SiO ₂ %	60-70
Al ₂ O ₃	15-30
FeO	1-5
CaO	.005-1
MgO	.005-0.5
Na ₂ O	.005-0.5
K ₂ O	.001-0.5
TiO ₂	trace
Carbon (organic)	.01 - .8
SO ₃	0.3-0.75
L.C.I.	3-10

Ceramic Characteristics

P.C.E.	Cone 7-8
Colour (fired)	Buff Red - Brown
Shrinkage (total)	5%

Fluoride Analysis - 200 - 2000 ppm (raw)





Research Information

INTERSTATE BRICK AND CERAMIC TILE

October 20, 1982

Mr. Howard Penn
Research And Development
Brampton Brick LTD
514 Main Street N.
Brampton, Ontario
L6V 1P9

Dear Mr. Penn,

After your recent visit and tour of Interstate Brick facilities to obtain information about the state of the art for scrubbing kiln exhaust gases for flourine, you asked for the following information: the annual operating costs for scrubber on line four and scrubber test data for lines one, two, and three.

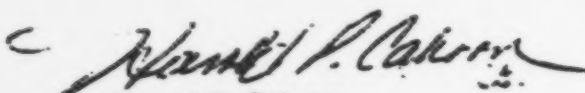
The operating cost for the scrubber on line 4 are listed below and are based on 18 cars per day, 52 weeks per year:

Supplies, lime etc.	\$12,300
Maintenance (cleaning)	9,125
Power	4,420
Water	2,100
Depreciation	19,600
Tax	13,600
Total	\$42,145

The test data for scrubbers one, two, and three are given in the inclosed sheets. The test in 1973 was done by Clemson University. All the other test were done by American Chemical And Research Laboratories.

I hope this information will be helpful. If you need additional information please do not hesitate to ask.

Sincerely yours,


Harold P. Cahoon

SHOWROOM, SALES OFFICES & DISTRIBUTION CENTER

WEST JORDAN FACILITIES
General Office and Manufacturing Plant
8210 South 8300 West
West Jordan, Utah 84084
Phone (801) 561-1471

SALT LAKE FACILITIES
3037 South 300 West
Salt Lake City, Utah 84115
Phone (801) 467-0801 and 561-1471

OGDEN FACILITIES
880 West Avenue
Ogden, Utah 84404
Phone (801) 394-7701 and 561-1471

ST. GEORGE FACILITIES
1156 East 350 North
P.O. Box 611
St. George, Utah 84770
Phone (801) 673-0801 and 561-1471

1973
Plant No. 1
TABLE 2

POLLUTANT CONCENTRATIONS IN KILN EXHAUST GASES

BEFORE SCRUBBER

205 ppm HF

135 ppm SO₂

12 ppm SO₃

AFTER SCRUBBER

2.9 ppm HF 98.59% eff.

107 ppm SO₂

12 ppm SO₃

TOTAL GAS FLOW THROUGH SYSTEM 22,000 acfm (DRY)

TABLE III

STACK GAS ANALYSIS AND SCRUBBER EFFICIENCY

Sampling Date- June 16, 1976

Sample Location	Temp. (°F)	(Volume %)			% N ₂	S	$\frac{\text{mg/ft.}^3}{Y}$ (Stand. P.T.) • Static Press.	
		% CO	% CO ₂	% O ₂			NO ₂	in. H ₂ O
#1 Scrubber In	535°	0.1	2.10	13.60	84.30	14.99	6.93	0.038
#1 Scrubber Out	122°	0.1	3.23	16.75	80.00	3.69	0.01	0.027
#2 Scrubber In	490°	0.1	2.00	18.30	79.70	16.83	7.90	0.1
								4.4

% Removal

Scrubber Efficiency

#1	75.38 %	99.86 %
----	---------	---------

TABLE IV

STACK GAS ANALYSIS AND SCRUBBER EFFICIENCY

Sampling Date- July 26, 1976

Sample Location	Temp. (°F)	% CO	(Volume %) % CO ₂	% O ₂	% N ₂	S	$\frac{\text{mg/ft.}^3}{\text{ft.}^3}$ (Stand. P.T.) NO ₂	Static Pressure (in. H ₂ O)
Scrubber In	470.2	< 0.1	1.0	15.0	81.0	14.68	1.801	0.0001
Scrubber Out	126.2	< 0.1	2.5	15.6	81.9	14.48	0.043	0.0015
Scrubber In	514.7	< 0.1	0.8	18.0	81.2	9.97	7.91	0.0004
Scrubber Out	214.0	< 0.1	2.0	18.1	79.9	7.53	3.59	0.0032

% Removal

Scrubber Efficiency S

	% Removal
#1	1.36 %
#2	24.47 %

TABLE V

STACK GAS ANALYSIS AND SCRUBBER EFFICIENCY

Sampling Date- September 28, 1976

Sample Location	Temp. (°F)	% CO	(Volume %) % CO ₂	% O ₂	% N ₂	$\frac{\text{mg/ft.}^3}{\text{ft}}$	(Stand. P, T) Static Pressure NO ₂ (in. H ₂ O)
Scrubber In	130.0	-	-	-	-	31.91	6.41
Scrubber Out	120.0	-	-	-	-	6.01	0.48
Scrubber In	130.0	-	-	-	-	43.37	5.54
Scrubber Out	130.0	-	-	-	-	12.17	0.34
							51.1
							04.1
							4.7
							04.1

Scrubber Efficiency % Removal

91 81.17 % 92.51 %

92 71.94 % 93.86 %

BIOCHEMICAL EXPLORATION
 POLLUTION ANALYSIS (HUMPHREY)
 SOILS AND FERTILIZERS
 METALS
 SALTS AND BRINES
 BIOCHEMICAL
 ENVIRONMENTAL BACKGROUND
 CROPS AND PLANTS
 COKE AND COALS
 WASTEWATER EFFLUENTS
 GASES

May 11, 1977

Mr. Harvey Cahoon
 Plant Manager
 Interstate Brick
 9210 South 5200 West
 West Jordan, UT

Dear Harvey:

Included herewith are the results for the December 28, 1976 and January 6, 1977 stack tests. As discussed earlier, some problems were experienced in obtaining samples the day the surfactant was put into the scrubbing solution (on 12-28-76). To alleviate the problems encountered on the December 28 sampling, a liquid-trap system was used for the January 6 sampling.



American
 Chemical

&

Research
 Laboratories

Sample Location	Date	S(mg/ft ³)	F(mg/ft ³)
#1 Scrubber In	12-28-76	9.91	10.16
#1 Scrubber Out	12-28-76	10.57	11.20
#1 Scrubber Out	12-28-76	16.72	20.29
#1 Scrubber In	1-6-77	7.53	0.205
#1 Scrubber Out	1-6-77	6.82	0.024
#2 Scrubber In	1-6-77	7.94	0.293
#2 Scrubber Out	1-6-77	5.18	0.009

As per our April 20 meeting agreement, we have been taking agricultural samples around the plant in 8 directions. These samples will be analyzed for fluoride only and reported as soon as they are completed.

When weather permits, we will sample in and out of the scrubbing towers for sulfur, fluoride, nitrogen dioxide, and ammonium ion.

Sincerely,

V. Brent Benson

V. Brent Benson

American Chemical & Research Labs

VBB:sv

Interstate Brick Company

Plant No. 3

A - Stack Analysis - (Scrubber #2) 5/10-77

Sample Port.	Temp. (°F)	Fluoride mg/ft ³	Amonia mg/ft ³	Sulfur mg/ft ³	Nitrogen Dioxide mg/ft ³
In.	525	0.804	0.047	8.20	.
Out.	124	0.023	0.035	10.39	.

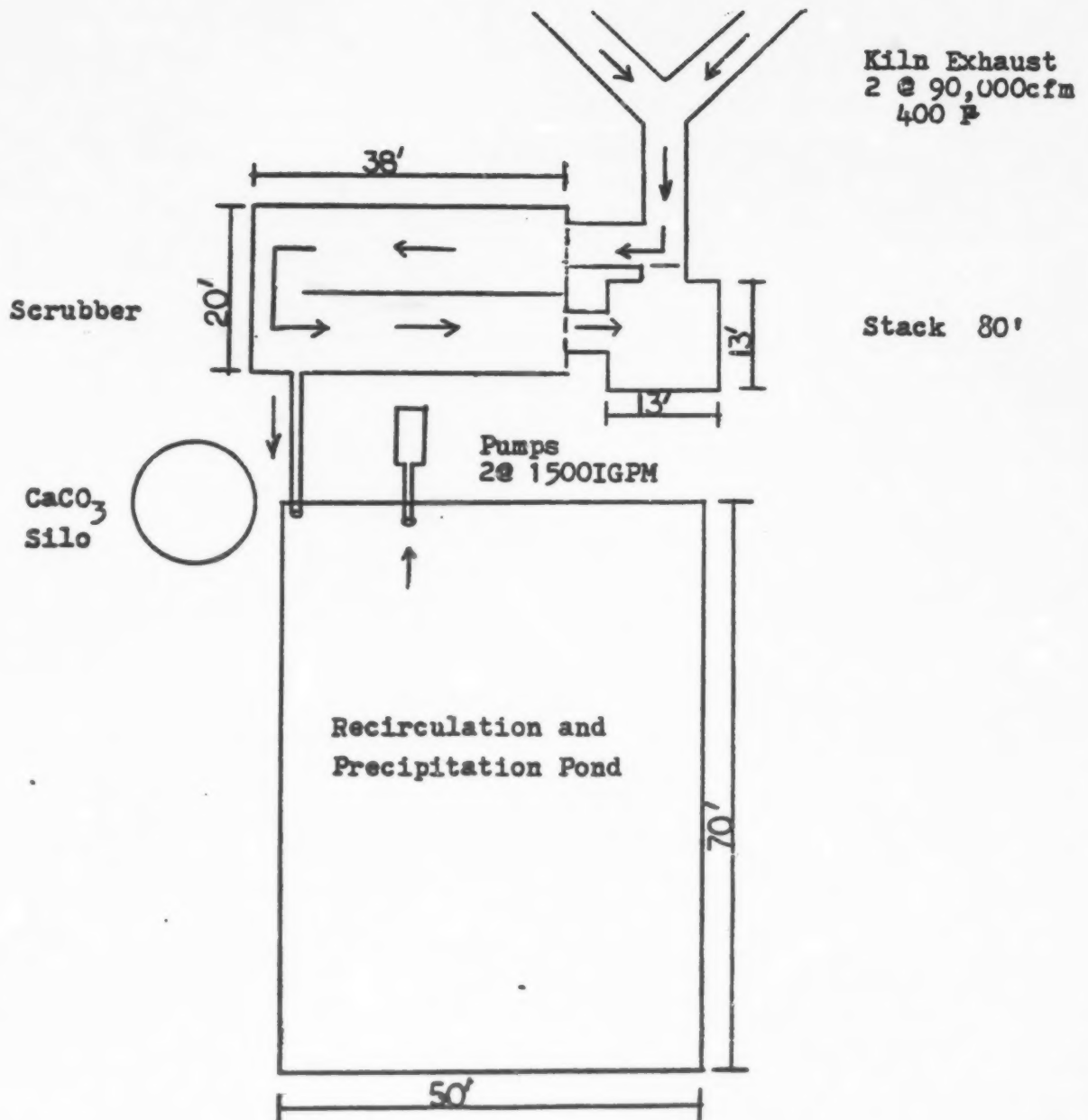
97.14% eff.

2 - Samples were bleached by fluoride prior to returning to laboratory.

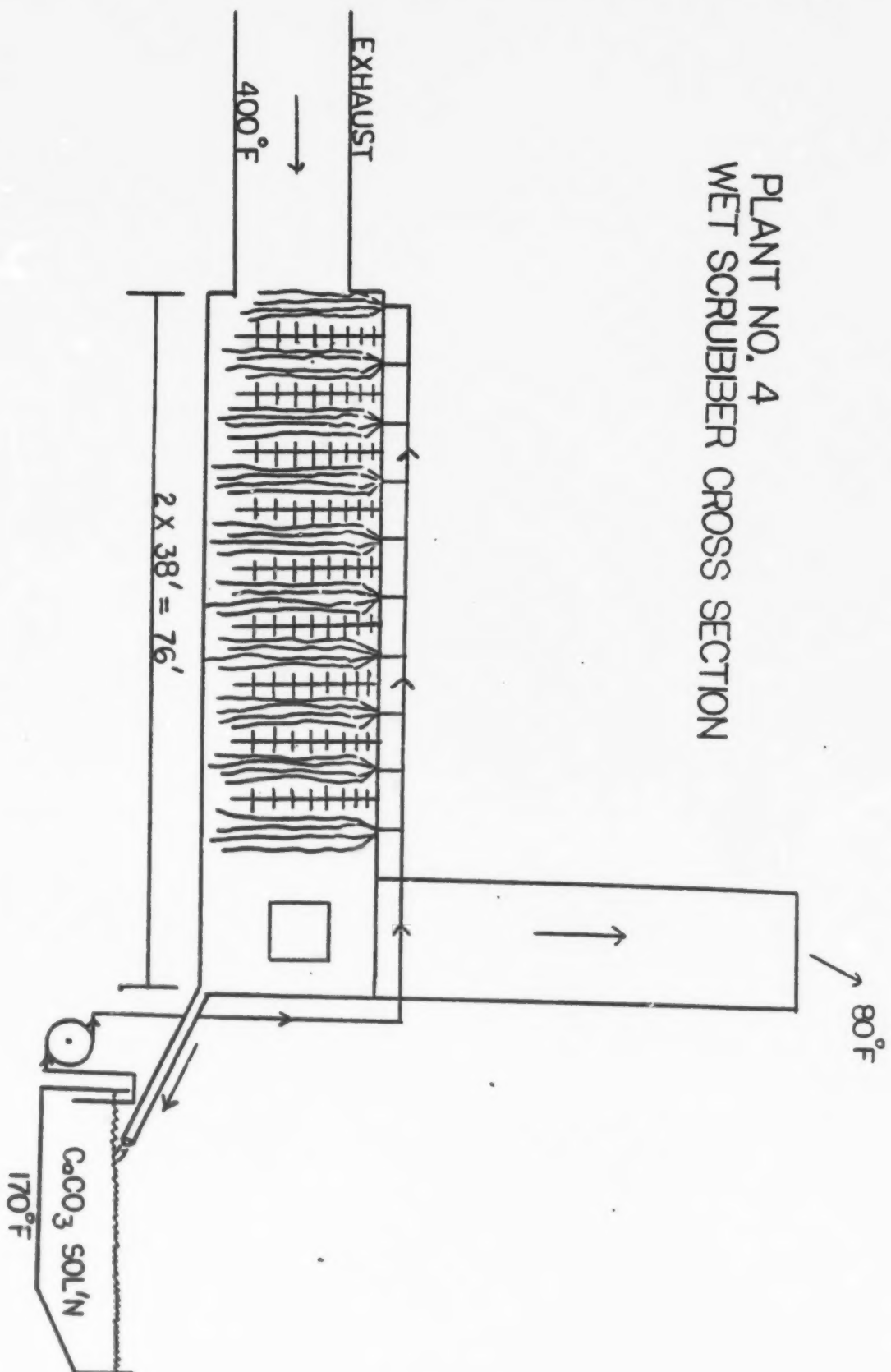
INTERSTATE BRICK

WET SCRUBBER

PLANT NO. 4



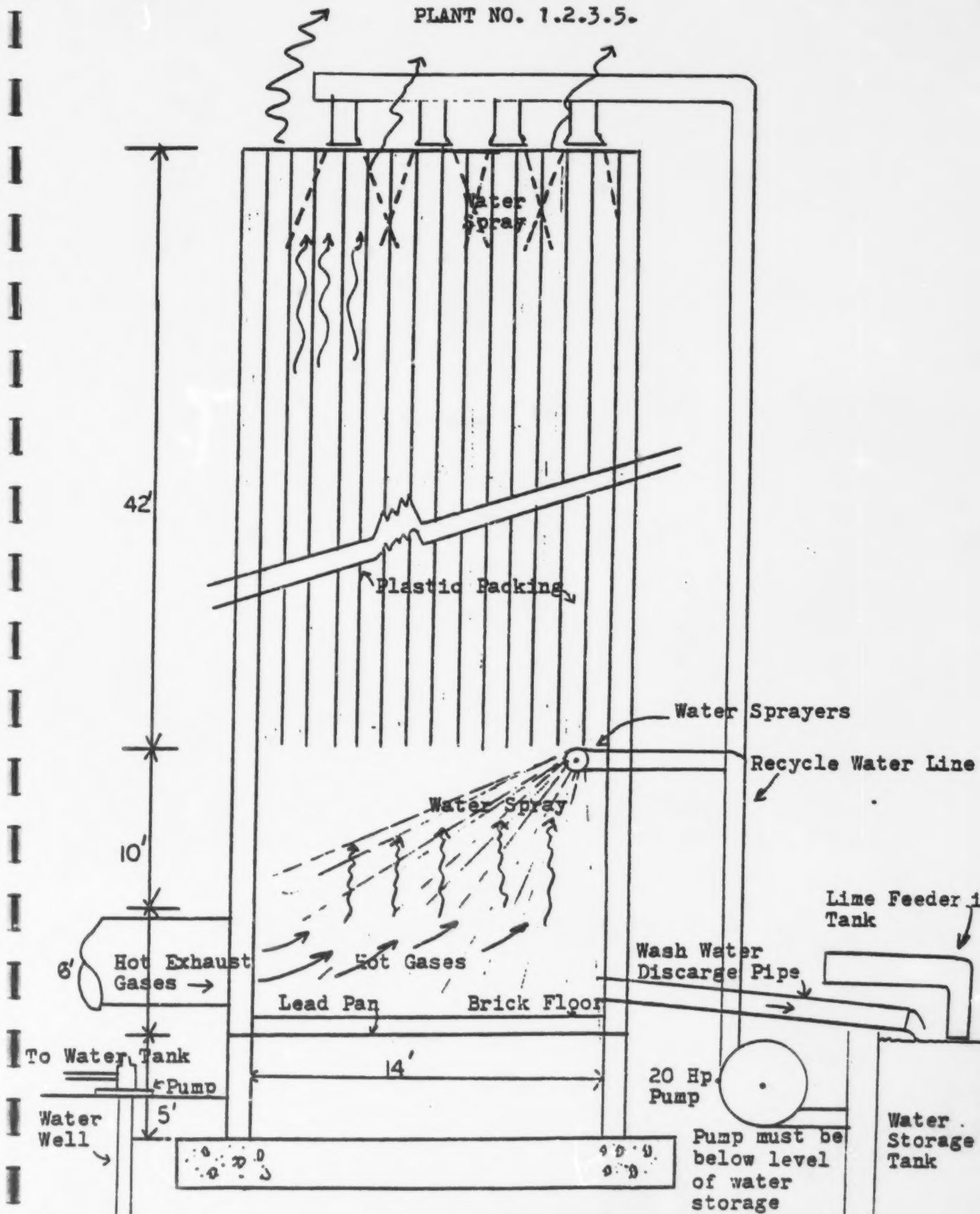
PLANT NO. 4
WET SCRUBBER CROSS SECTION



INTERSTATE BRICK

WET SCRUBBER

PLANT NO. 1.2.3.5.



INTERSTATE BRICK
PRECIPITATION POND

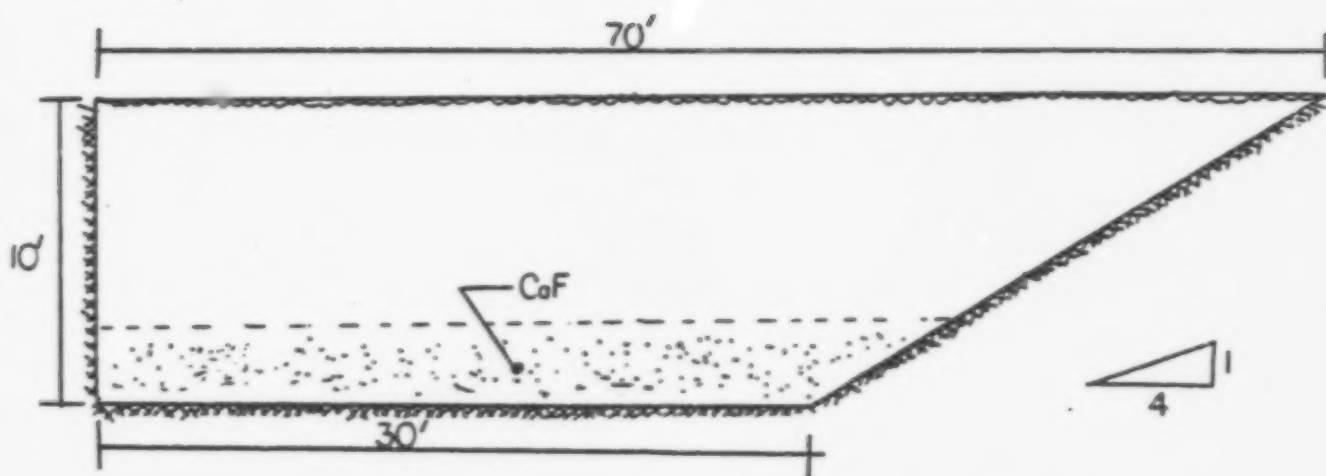




PHOTO 1

Wet Scrubber system for Plants 1, 2, and 3 (R to L)
Adjacent to the 3 (60 ft.) stacks is the 40 ft. silo
for calcium carbonate. The two stacks on the right
share a settling/recirculation pond, while the extreme
left stack (Plant 3 - Keller coal-fired unit) has its
own settling/recirculation pond.

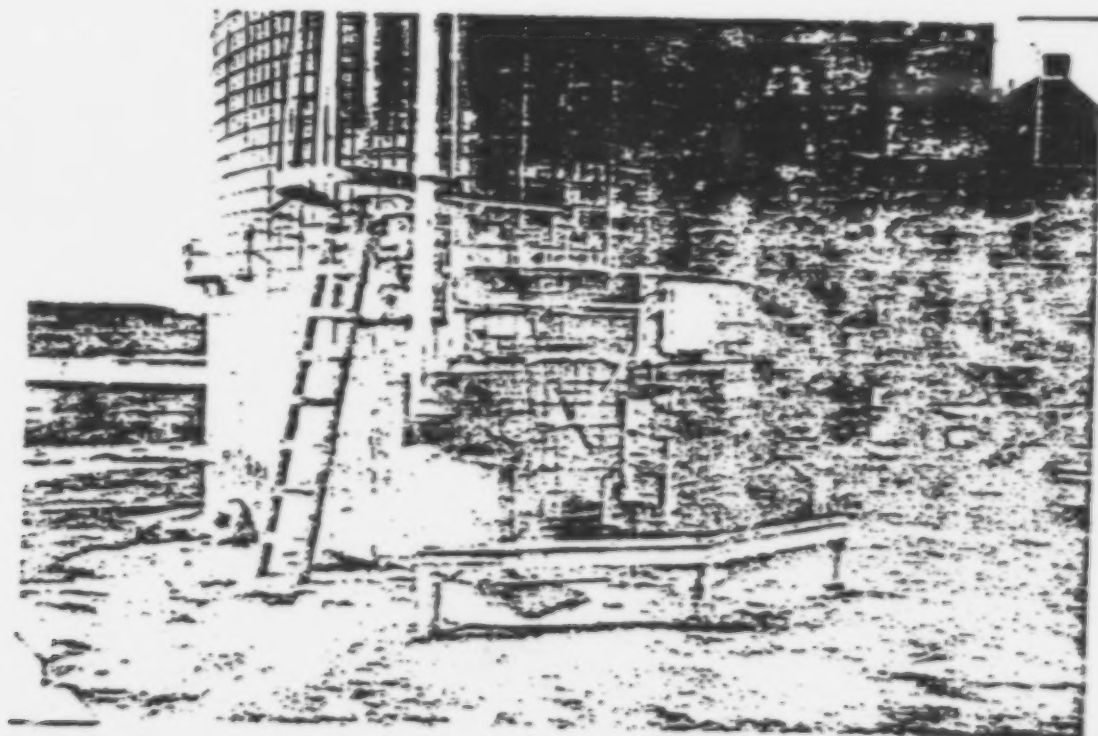


PHOTO 2

The calcium carbonate silo utilizes a compressed air system to prevent the chemical from packing up.

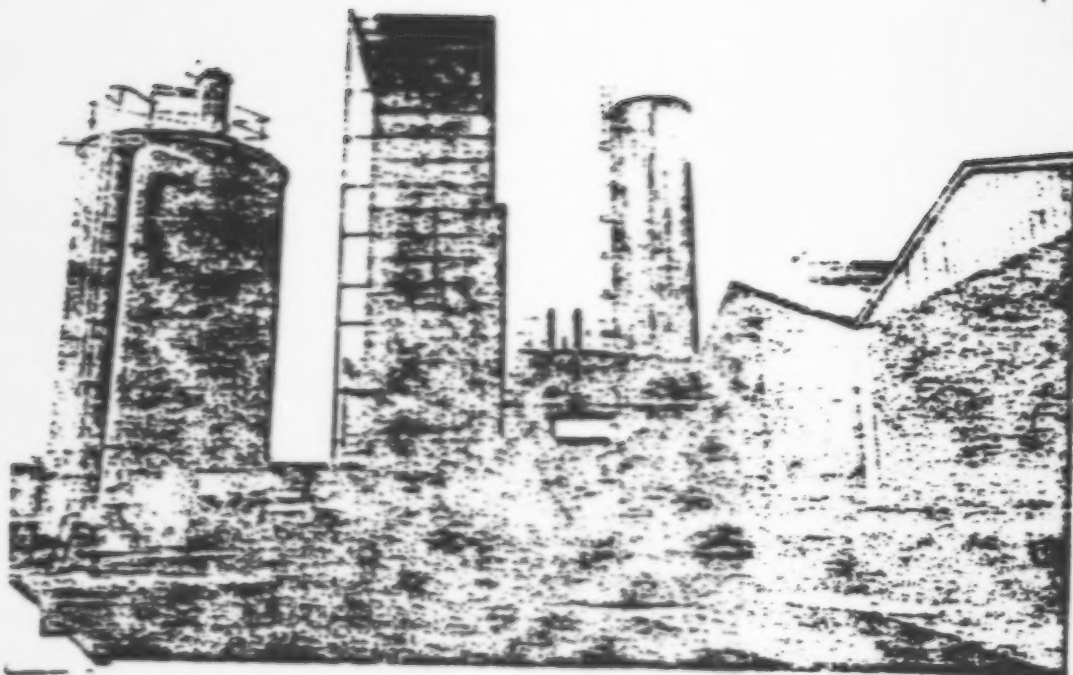


PHOTO 3

This photo illustrates the Wet Scrubber system for Plant 1. Note the exhaust gases from the building and then is directed to, first to the side of the vertical scrubber system. A 60 ft. water tank stands behind the latter, exhaust gases and supplied water for all 3 wet scrubber system. See also Photo 1.

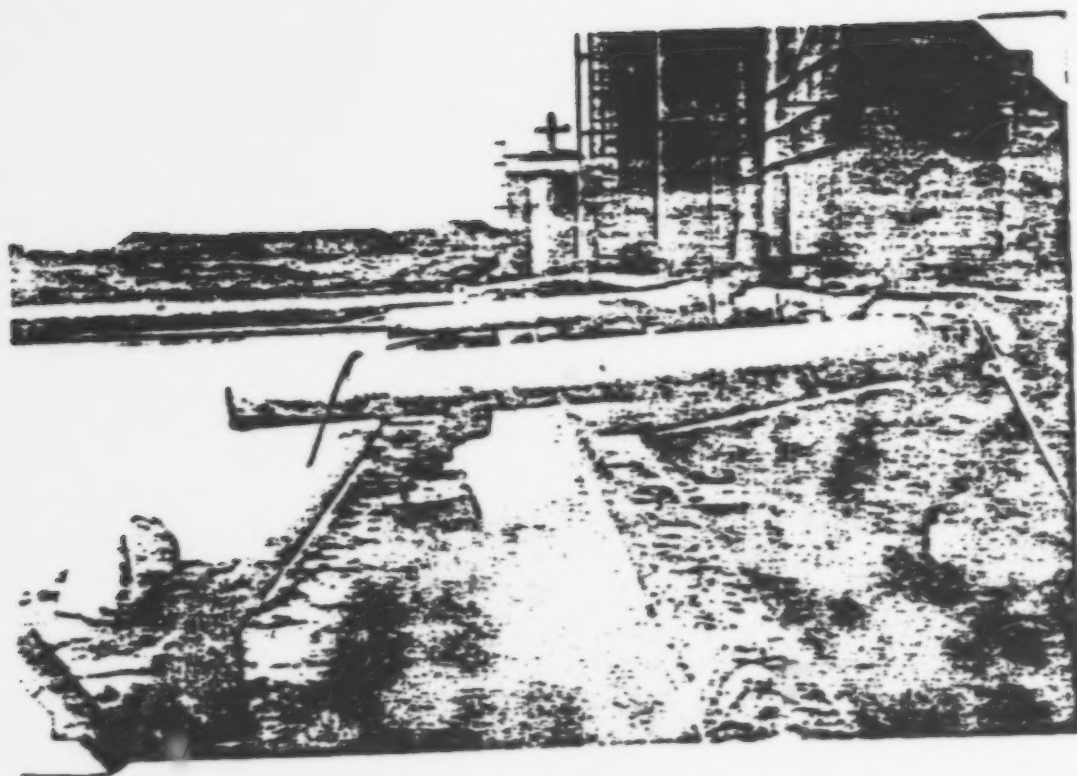


PHOTO 4

.This photo illustrates the discharge outlets for the wet scrubber systems on Plants 1, 2, and 3. There is the option for Plant 3 to discharge into the recirculation/settling pond for Plant 1 and 2 or vice versa.

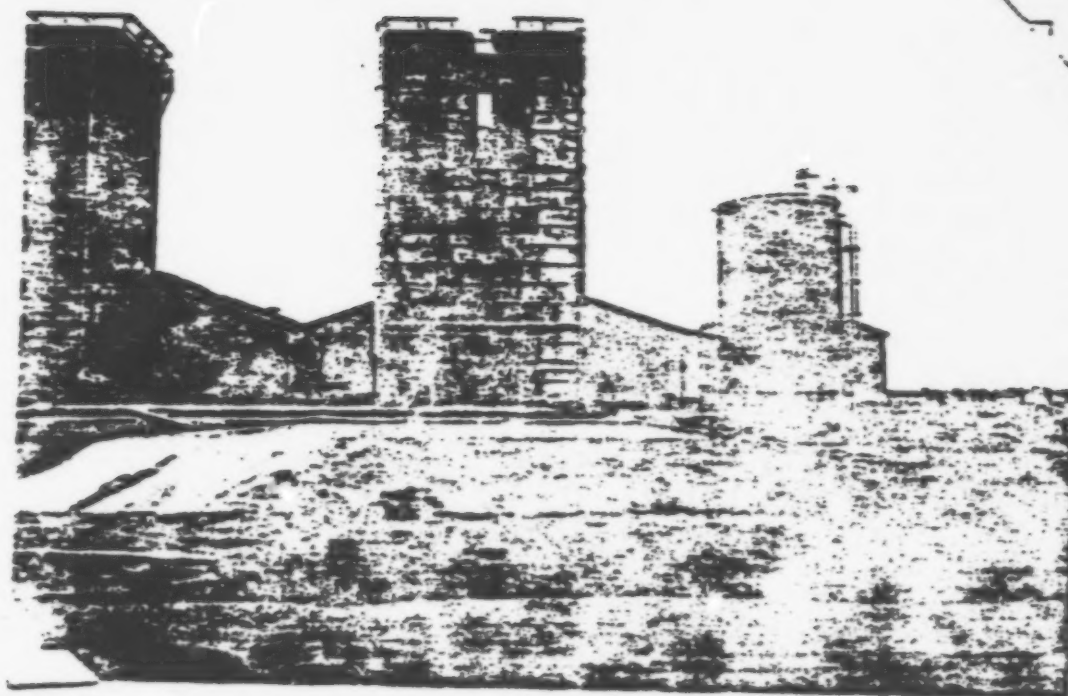


PHOTO 5

Recirculation/settling pond for the wet scrubber system for Plants 1 and 2. At this time only Plant 2 was operating and consequently, discharge from left pipe can be seen.

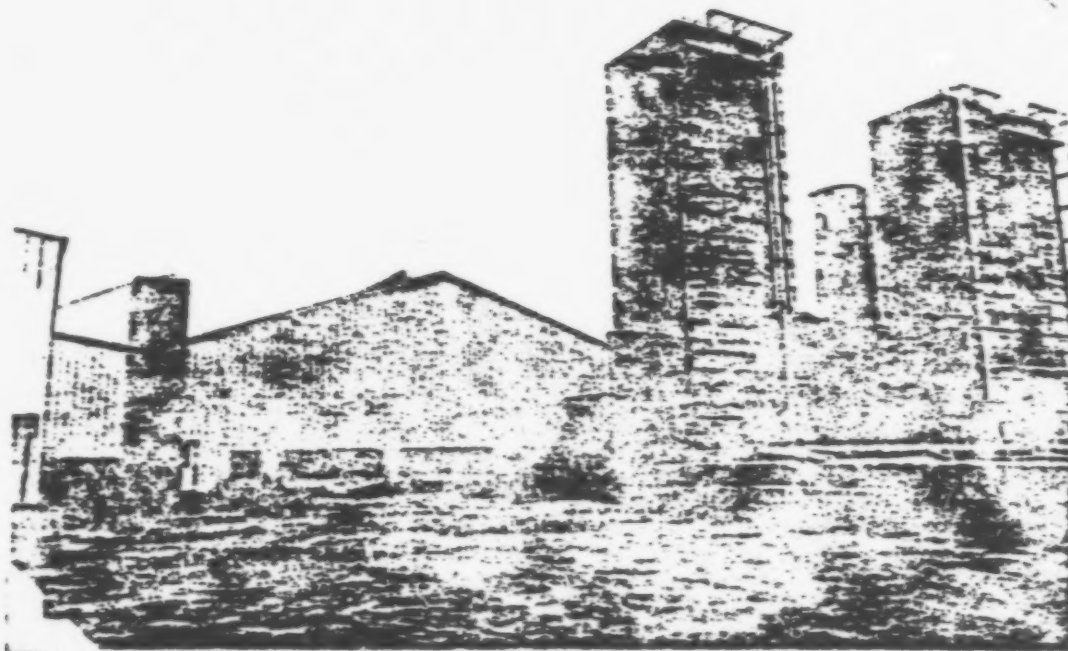


PHOTO 6

This photo illustrates the wet scrubber system for Plant 3 (Keller coal-fired plant). The difference in the exhaust feed system to the wet scrubber from Plant 1 and 2 is that a bypass is not required. The small stack, positioned in the center of the plant, is for venting purposes during maintenance periods.

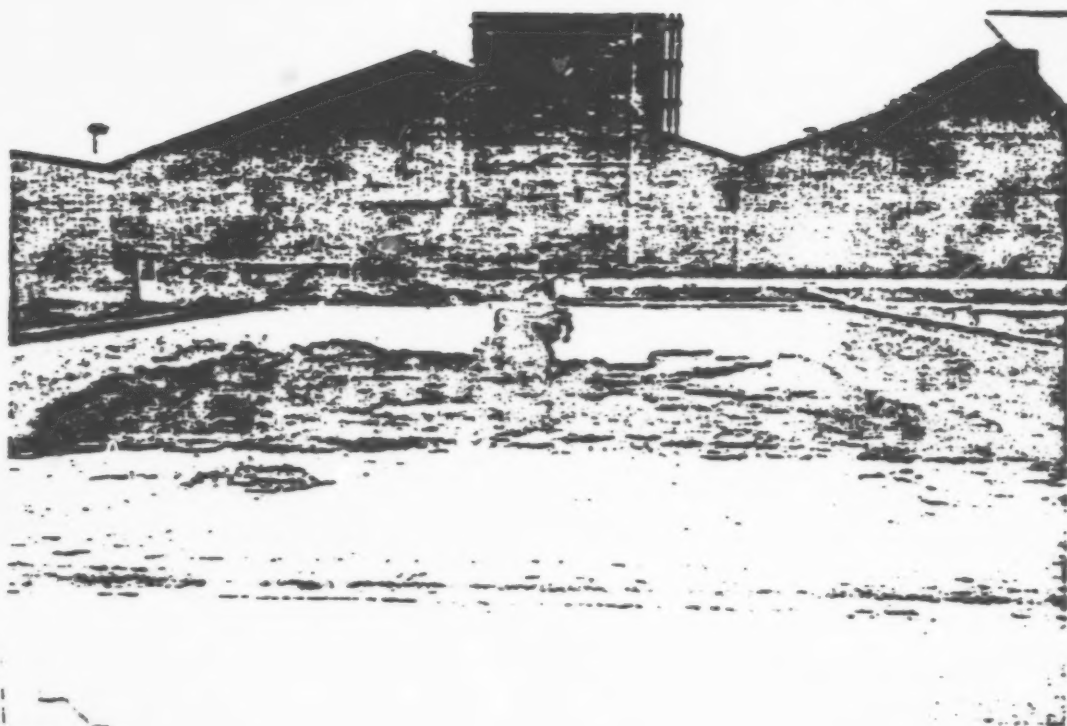


PHOTO 7

This is the recirculation/settling pond for Plant 5 (presently not operating). It has been partially cleaned out, but still noticeable are the particulates of fly ash (greyish) and calcium fluoride (whitish, in right corner). The sloped grade (4:1) enables a front end loader to clear out the pond quite easily.

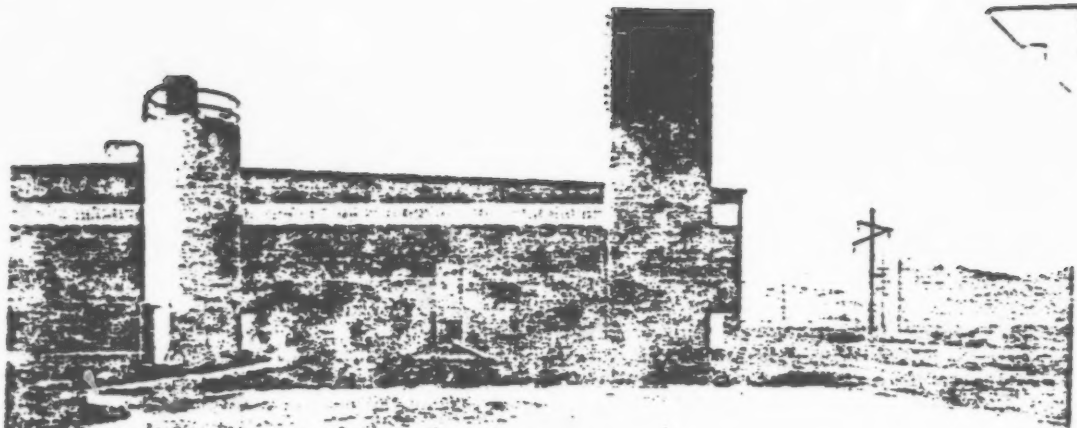


PHOTO 3

This photo illustrates the wet scrubber system for Plant 4 (1980 Hannon Kiln). Note, from left to right, the calcium carbonate silo, the horizontal scrubber system, the 20 ft. exhaust stack, the pump house (in front of the scrubber system) and the recirculation/settling pond.

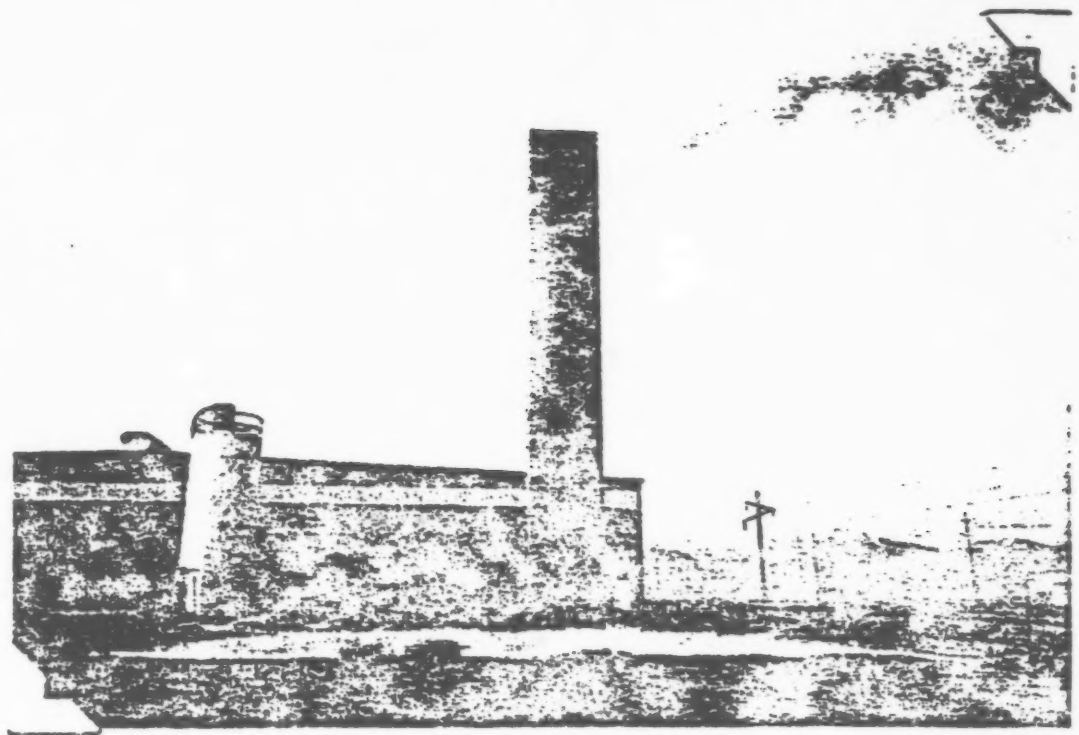


PHOTO 9

Another perspective of Photo 4 illustrating the exhaust from the stack. The feed system of the exhaust gases from the tunnel kiln is underground from the building.

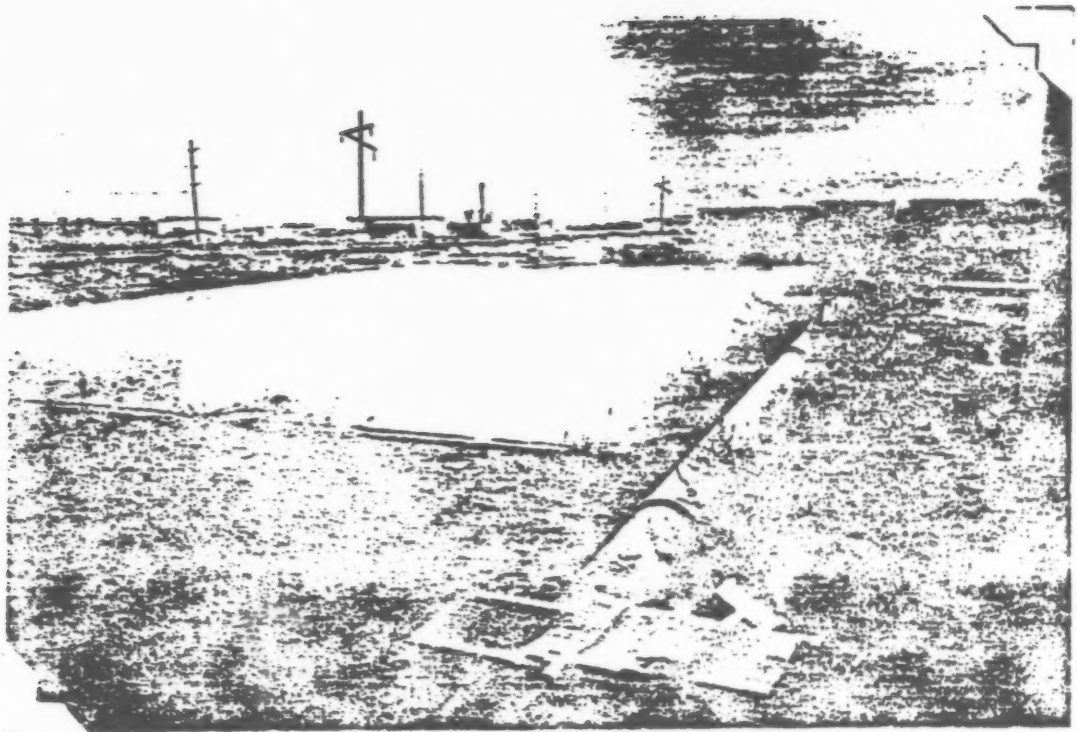


PHOTO 10

This photo illustrates the mechanical single auger feed system from the calcium carbonate silo to the PVC effluent discharge pipe leading to the recirculation/settling pond.

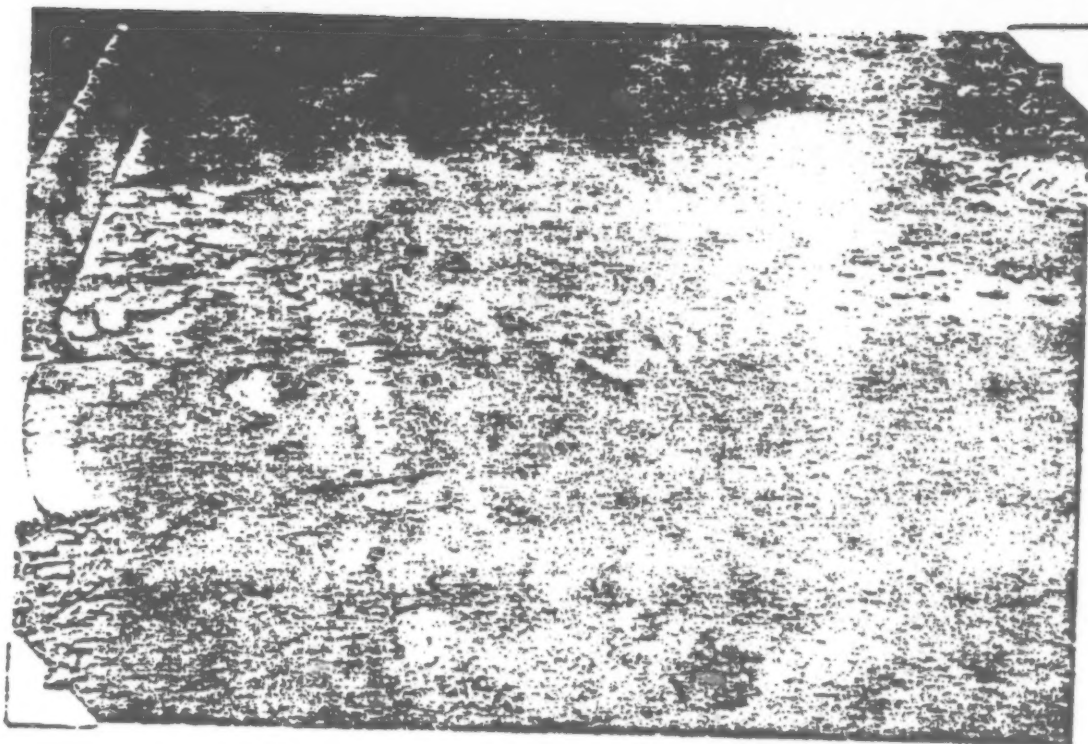


PHOTO 11

This photo illustrates the output in the PVC effluent discharge pipe for sampling and daily pH testing.

BRICKMAKING

Huge new Interstate Brick & Ceramic Tile Co. plant features widest tunnel kiln in Western Hemisphere. Producing 16-in. units, the facility can manufacture 80 million brick equivalents per year

By: P.E. Jeffers, Editor

Interstate Brick & Ceramic Tile was founded by John P. Cahoon, grandfather and great-grandfather, respectively, of its current president Harold P. Cahoon and vice president Harvey P. Cahoon.

John P. Cahoon started brickmaking in 1878 with a simple field kiln. The business, incorporated in 1891 as Salt Lake Pressed Brick Co., became Interstate Brick Co. in 1936. In 1971, the firm merged with Entrada Industries, a subsidiary of Mountain Fuel Supply Co. In 1972, the plant was moved to its present West Jordan site.

It seems logical that when you want to manufacture large size brick, you build a big plant. And a big plant is what Interstate Brick & Ceramic Tile, a subsidiary of Mountain Fuel Supply Co., built at its West Jordan, Utah location. The plant produces a new 16-in. Atlas™ brick that could become the product of the future for builders in Salt Lake City and other Western locations. Advantages to builders are many, including faster laying time, double wall finish, structural integrity, aesthetic freedom and the durability of fired brick. Produced in 4- by 4-in., 6- by 4-in. and 8- by 4-in. sizes, the brick have large core holes for insulation or reinforcement. The new 16-in., through-the-wall brick are an extension of the already successful 12-in. Atlas™ units.

A 190 million brick/yr potential

Interstate Brick has two other plants at the West Jordan site capable of producing 110 million brick per year. Add the new plant's capacity of 80 million brick equivalents per year, and the 190 million total may be the largest

production capacity of any single location in the Western United States. All of this came into being since 1972. Also at the West Jordan site is a small ceramic floor tile operation.

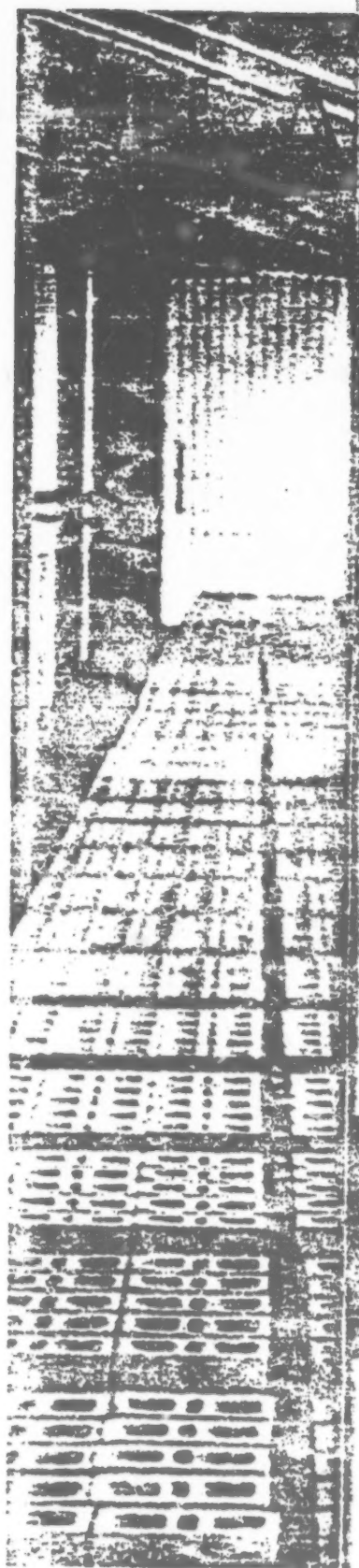
Clay preparation for the new plant takes place in a grinding-screening plant built in 1972. This plant, seeming oversized back in 1972, now really comes into its own. The only major addition involved two 5- by 10-ft screens included when the new plant was plugged in.

Ground material is conveyed to the new plant and placed in large storage bays. Approximately 4000 tons, or one week's storage, can be accommodated in these bays. Two reclaimers work from one end to the other, scraping the ground clay into the production feed conveyor.

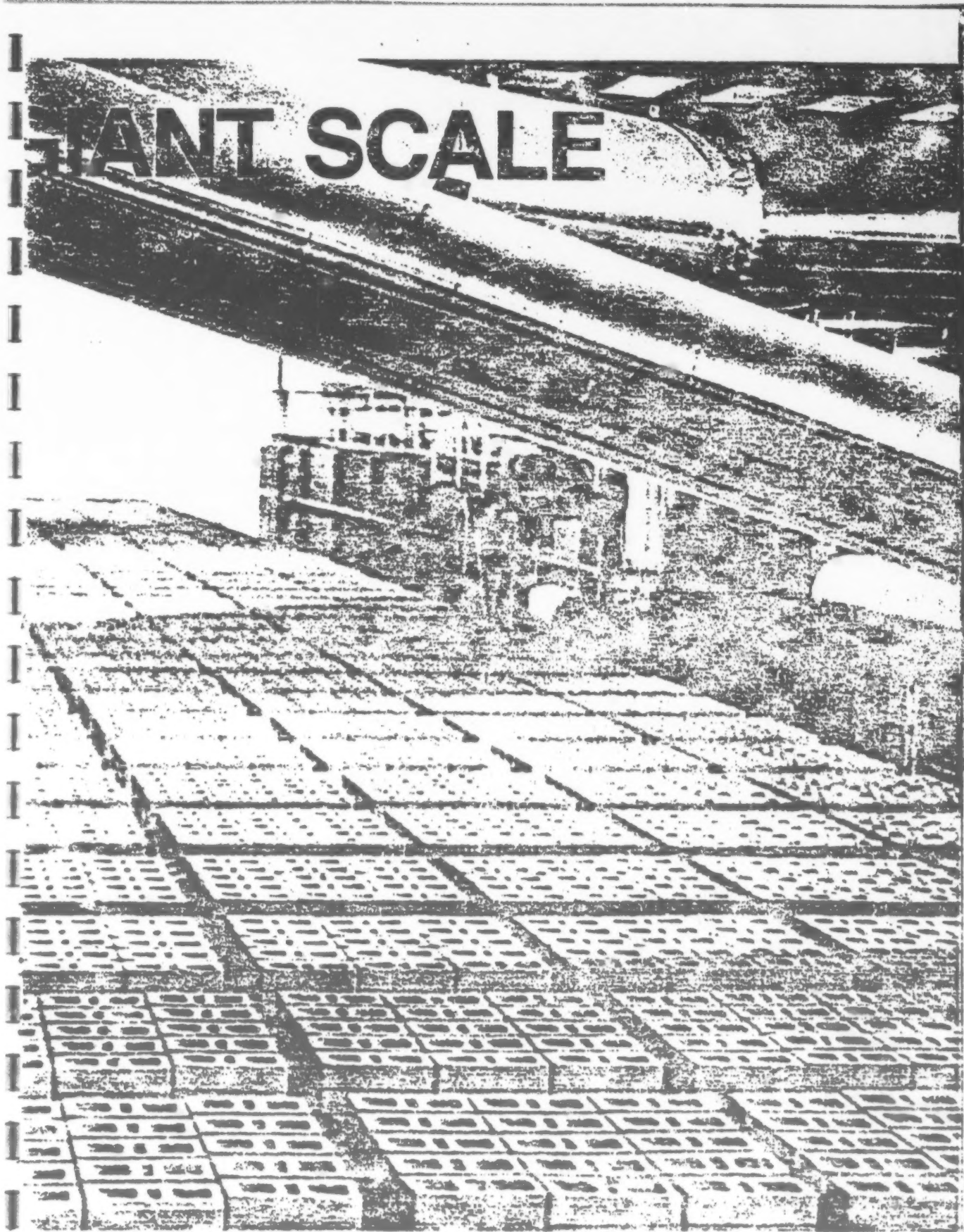
At a station between the storage room and production room, small digital weighing belt feeders deposit barium carbonate and any other necessary additives on the production feed conveyor.

There are two extrusion lines in the production room, i.e. one No. 40 extruder, reel cutter, an off-bearing belt for special shapes and a No. 90 extrusion line for the regular brick production. The special shapes line is operated only as needed.

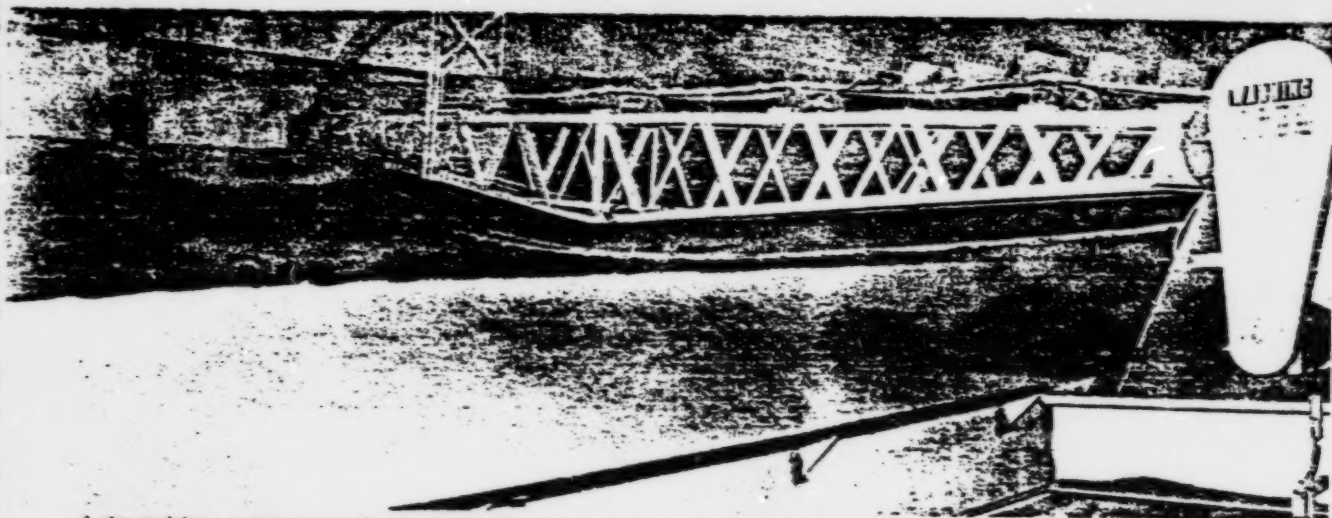
About 15 percent moisture is maintained at the main extruder, using a microwave system for measurement and control. The column is cut into slugs using a guillotine-type cutter. Each slug moves by conveyor to the push-through multiwire cutter. Because of the size of the column, the slug swings upward in an arching fashion as it is pushed through the multiwire set. This way, the table under the slug gives full support on



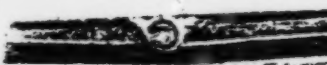
GIANT SCALE



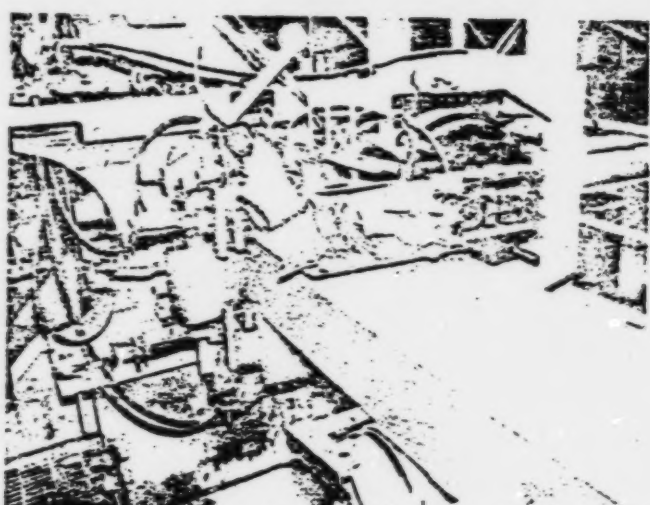
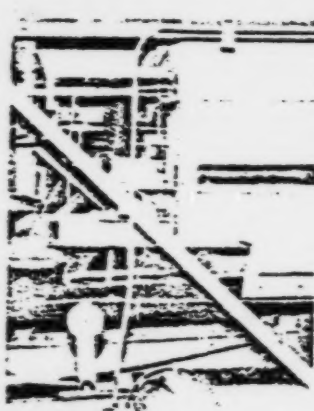
Setting width is equivalent to 36 standard brick.



A clay reclaiming system moves the ground clay from the storage area to the production conveyor.



Barium carbonate, manganese and other additives are deposited on the production conveyor by feeders as needed.



Column is extruded and trimmed.

Atlas brick could become product of future

the underside and minimizes distortion and tearing of the bottom edges of the brick. This is important, since the brick must have two good faces. A special device directs a blast of compressed air into the core holes to clean out any scrap that may have fallen in, which might cause later problems.

Cut brick move onto a marshalling table where they are picked up by a transfer gripper handling six rows with 20 brick per row. They are deposited on the six row, plastic topped chain conveyor which moves into a star-wheel turnover device. At this point the brick are turned to a flat position. In order to protect the two faces, all brick are flat set for drying and firing.

As soon as 10 rows are in place, a

second transfer gripper moves the brick to the pallet conveyor. Here they sit on metal slat pallets which are conveyed to the loading elevator.

Pallets are assembled in groups of six and lifted into the pallet elevator. This continues automatically until the elevator is filled with eight tiers of six pallets each.

At that point, a fork-type lifting device moves into the elevator, removes the eight tiers of pallets and places them on a dryer car. The loaded dryer car moves into position automatically for charging into the dryer.

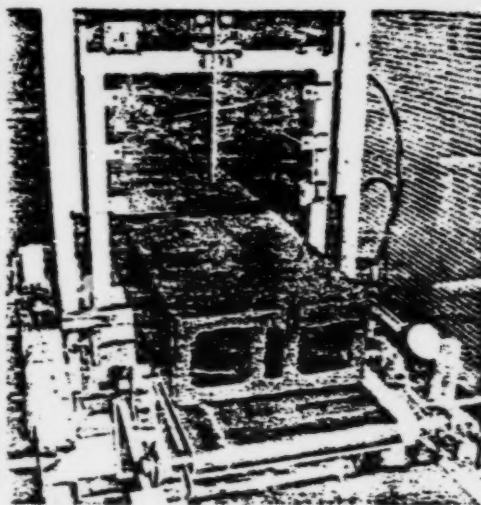
Three tunnel dryer

The dryer has three tunnels, with two tracks per tunnel. Waste heat from the kiln dries the brick to the point necessary

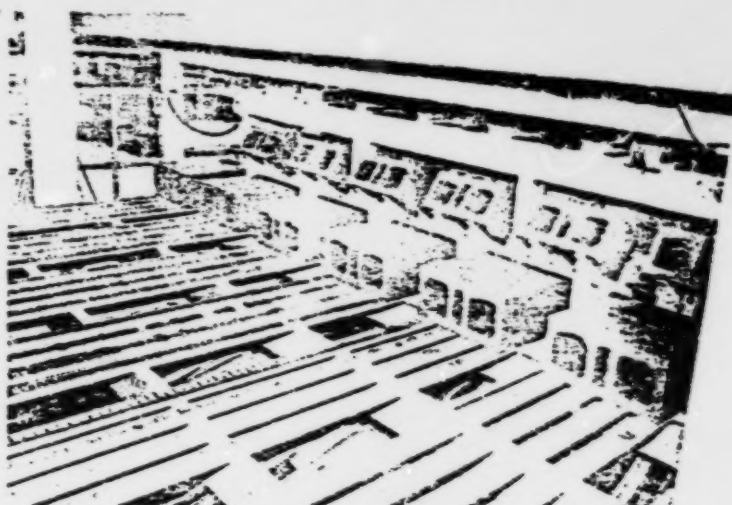
for automatic setting. A small percentage of moisture left in the brick allows setting with a minimum of breakage. The dryer can, however, completely dry the brick. Recirculation within the dryer is provided through openings in the hollow side walls. Air is cycled from right to left, then back left to right according to a program.

When a dryer car exits the dryer, the pallets are unloaded into an elevator in a process just reverse of the loading operation. Brick pallets are marshalled into groups of six and a four-head gripper transfers the brick two high and four packs, or one-third of a kiln car with each pass. The setting on the kiln car is 14 courses, flat set.

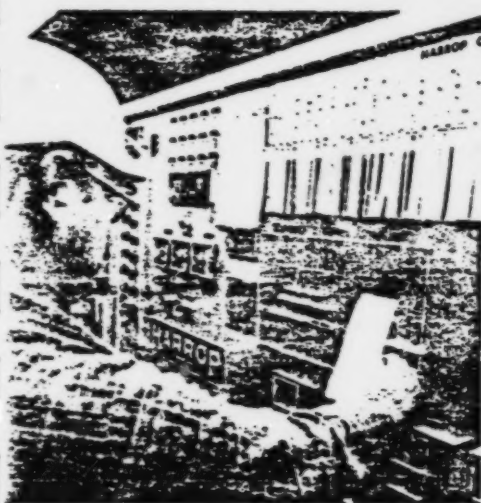
Pallets return to the loading area via



Guillotine wire cutter separates column into slugs.



Star-wheel turnover places the brick into the flat position.



There are no strip chart recorders on the kiln. Digital readings are recorded and monitored.



Gripper picks up the brick then moves them to a plastic-topped chain conveyor.

an overhead conveyor. They go to a storage magazine for future loading. The system utilizes 4700 perforated sheet metal pallets, 16 in. wide, 110 in. long and 3 in. deep.

After the kiln cars are loaded they transfer automatically into an insulated holding room. There's enough room in this holding room to accommodate car storage for a three-day weekend. Moist air can be exhausted. Introduction of waste heat into the holding room makes possible any desired environment. Distribution ducts direct air over and between the loads without direct impingement.

Cars are removed from the two-track holding room and transferred to a single track preheater.

The preheater holds 19 cars and provides a 24 hr finish drying time before brick enter the tunnel kiln. This completely removes any moisture that may still be in the brick from the pallet dryer, and any moisture picked up during the setting or holding operations. Cars exit the preheater at a temperature of 450°F and are placed immediately into the vestibule of the tunnel kiln.

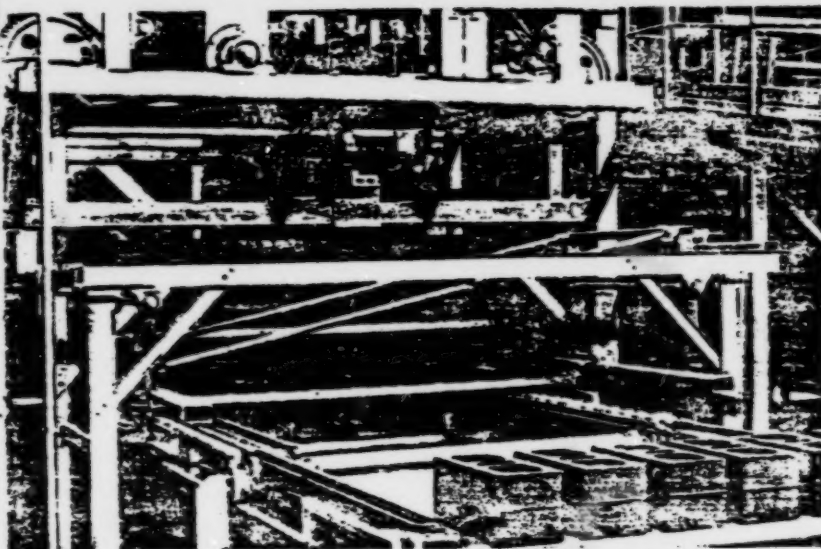
Widest kiln in Western Hemisphere

The tunnel kiln, considered to be the widest in the Western Hemisphere, is also among the largest for production. It is 26 ft 8 in. wide, or equivalent to 36 wide standard brick. The length is 509 ft. Production capacity rate is 80 million brick equivalents per year.

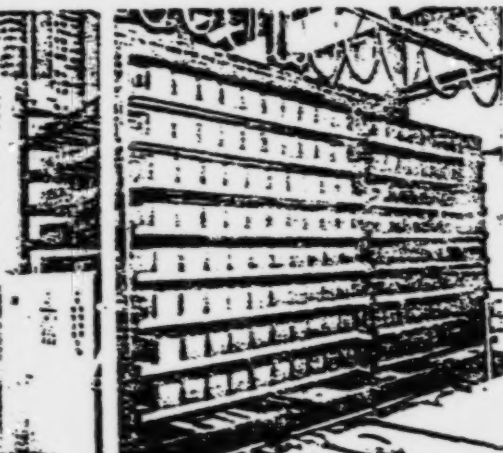
Kiln walls are made up of a dense refractory lining, high temperature insulating board, diatomaceous earth insulating powder and a red brick exterior. The suspended flat crown consists of special refractory shapes with shiplap joints in both directions. Crown insulation includes ceramic fiber blanket and of diatomaceous earth.

The combustion system employs natural gas, but provisions have been made for future solid fuel use. The preheat section is equipped with manually-controlled high velocity burners. The remaining fire lanes utilize special multifuel burners in six automatic control zones. These burners can fire solid fuel as well as gas or oil.

There also is a flashing zone and a



Flat-set brick on pallets are moved into the loading elevator.



Loaded dryer cars transfer automatically into the dryer tunnels.



Interstate Brick & Ceramic Tile vice president Harvey P. Cahoon.



Plant is hailed as one of industry's most important

quick cooling section. In the quick cooling section, tempered air is circulated through the fire lanes. Relief ports on both sides of the kiln remove heated air for use in the dryer or preheater.

The kiln holds 48 cars of brick and it usually requires about 2½ days to move a car through it. A maximum temperature of 2080°F is reached during this type of schedule. Maximum design temperature is 2300°F.

One interesting aspect of the kiln controls is that none of the usual strip chart recorders are used. All control points and kiln conditions are monitored by digital instruments and recorded on a tape printer. At some later time these could all be plugged into a computer system.

Scrubber protects environment

The kiln exhaust is removed through two masonry underground flues and into a scrubber system. Gases move through a series of polypropylene plates in the scrubber while lime water is sprayed from the roof. The water, which has absorbed sulfur and fluorine, falls to the floor and is pumped into a settling pond outside the scrubber. Lime added to the settling pond maintains a proper pH. This type system usually can remove 98 percent of the fluorine and 70 percent of the sulfur from the exhaust.

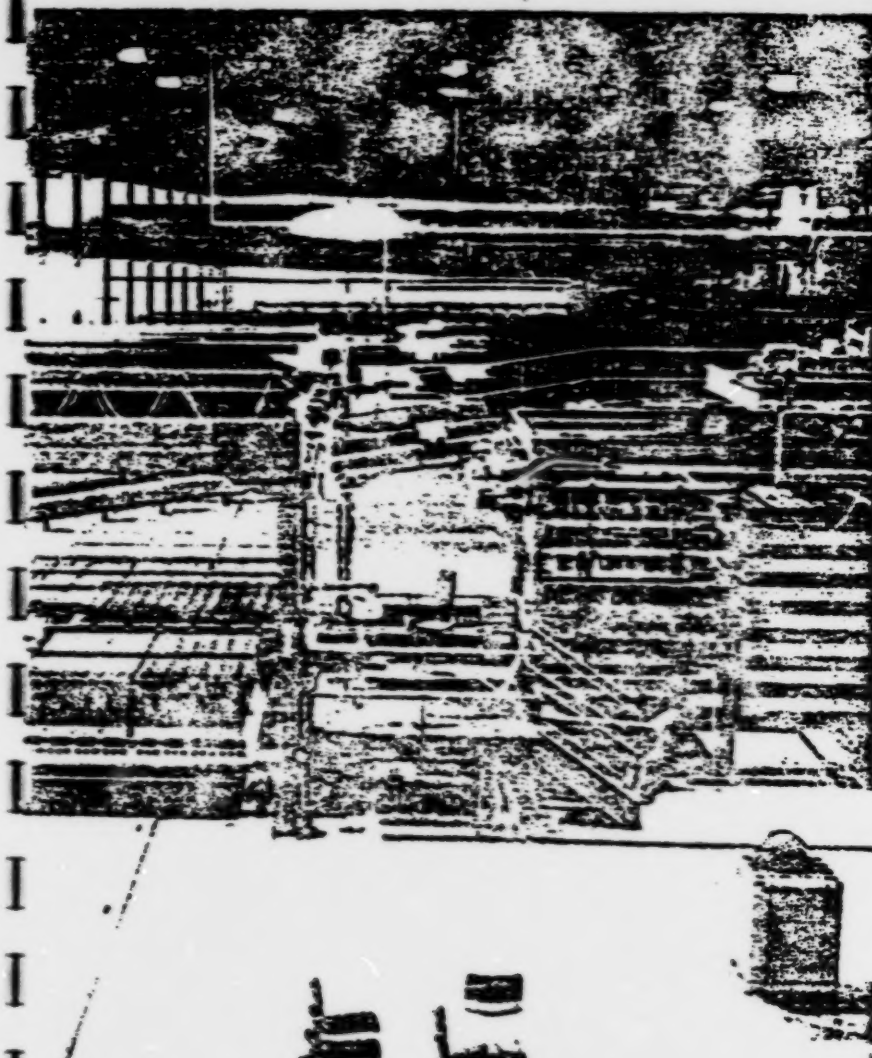
An acre of car deck

There are 136 kiln cars in the plant—nearly one acre of car deck area. Cars weigh approximately 109,000 lb.

including car steel, refractory deck, and a full load of brick.

Cars move from the kiln to a storage area where they are held until unloaded. There are two unloading tracks.

The need to inspect each brick for size, color and possible chipping dictates a manual unloading system. Empty pallets are brought to the plant by lift-truck and stacked onto a chain-type unloading conveyor manually. A crew of unloaders inspect and place each brick on the wooden pallets. Through-the-wall dimensions are held within ± 1/8 in. A sheet of styrofoam plastic between courses of brick prevents damage during shipment. Rejects are thrown through an open area against a wooden backstop where they fall on a scrap conveyor and



Setting machine moves the brick from pallets to the tunnel kiln cars.



Brick are inspected and palletized manually. Sheet styrofoam is used for protection between courses.



Metal bands tie the package.

are taken out of the plant.

Loaded pallets are strapped with metal bands and either conveyed directly out of the plant or sent through a shrink film wrapping station. A lift truck removes the finished package to storage or loads it directly for shipment.

Major development in brick industry

The new plant, dedicated last Aug. 3 in the presence of the Governor of Utah, the Mayor of West Jordan, the chairman of Mountain Fuel Supply Co., officials of Interstate Brick & Ceramic Tile, and representatives of the masonry industry, has been hailed as one of the most important developments in the American brick industry. The commitment that this company has made, not only in the

design of the plant but also in the potential of the product it produces, represents an example for brick manufacturers everywhere.

Equipment List for Interstate Brick
 Turnkey Contractor - Hanrop Industries Inc.
 Clay reclaimers - Walter C. Stoll & Sons
 Bins and conveyors - Walter C. Stoll & Sons
 Extrusion equipment - J. C. Steele & Sons, by Walter C. Stoll & Sons
 Cutter - J. C. Steele & Sons, by Walter C. Stoll & Sons
 Cutter - Lingi Trev
 Setting machine - Lingi
 Unloading and packaging - Lingi
 Palletizing - Lingi
 Pallet handling - Lingi
 Dryer - Hanrop Industries Inc.
 Holding room - Hanrop Industries Inc.
 Tunnel kiln - Hanrop Industries Inc.
 Fans - Robinson Industries
 Car tools - A. P. Green Refractories Co.

Kiln controls - Barber-Colman and Dorr
 Scrubber - Interstate Brick
 Strapping - Sargis Corp.
 Transfer Cars - Star Manufacturing
 Programmable controllers - Westinghouse

Approximate Metric Equivalents

1 1/2 in. = 37.5 mm
 3 in. = 75 mm
 4 in. = 100 mm
 8 in. = 200 mm
 9 in. = 225 mm
 0 1/2 in. = 12.5 mm
 15 in. = 400 mm
 29 in. = 725 mm
 110 in. = 2.7 m
 5 ft = 1.5 m
 10 ft = 3 m
 508 ft = 152.7 m
 25 ft = 8 m
 126,400 lb = 56,290 kg
 4000 tons = 3600 t
 440 F = 232 C
 2080 F = 1333 C
 2300 F = 1250 C

INTERSTATE BRICK & CERAMIC TILE

INTERSTATE BRICK PRODUCTS PHYSICAL DATA

Following information compiled from actual testing data performed by independent testing laboratories; i.e., Pittsburgh Testing Laboratory and American Testing Laboratory, etc. (Official test papers available on request.)

I. STANDARDS, MODULARS, NORMANS (ASTM C216)

Compressive Strength, PSI

Most colors, *excluding Arctic White, Sahara Mist, Sudan Gray, Tiffany 10,000-12,000

NOTE: Bricks tested registered in excess of 300,000 lbs. and could not be broken on testing machine.

*For lighter color brick such as Arctic White, Sahara Mist, Sudan Gray, Tiffany, figure approx. 10% less.

Water Absorption by 5 Hr. Boll, percent

Most colors, *excluding Arctic White, Sahara Mist, Sudan Gray, Tiffany 6.5 to 9.5

*For lighter color brick such as Arctic White, Sahara Mist, Sudan Gray, Tiffany, figure approx. 10% more.

or data in (1) Max. Permissible extent of Chippage (Table 3); (2) Percentage of Shipment that may be Allowed Chippage (Table 4); (3) Tolerances on Dimension (Table 5); and (4) Tolerances on Distortion (Table 6)...Interstate Brick face brick products will generally conform to requirements of ASTM C216, Grade SW, Type FBX. Contact Interstate Brick for applicable specification needs and requirements if necessary.

II. CHIMNEY BRICK (ASTM C219)

Modulus of Rupture, PSI 2,728

Water Absorption 2 Hr. Boll, percent 5.3

Solubility in Sulfuric Acid, Loss in Mass 1.68%

III. PAVERS/FLOOR BRICK (ASTM C410 & C279)

Modulus of Rupture, PSI 1,955 Avg.

Water Absorption by 5 Hr. Boll, percent 7.38

Weight Loss by Chemical Resistance-Test, percent 5.41

For data in (1) Permissible Variations in Dimension (Table II); and (2) Tolerances on Warpage (Table III), Interstate Pavers/Floor Brick will generally conform to requirements of specification. Interstate Paving materials are intended for use where low absorption (less than 5%) is not required. Contact Interstate Brick for applicable specification needs and requirements if necessary.

INTERSTATE BRICK & CERAMIC TILE

INTERSTATE BRICK PRODUCTS PHYSICAL DATA (CONT.)

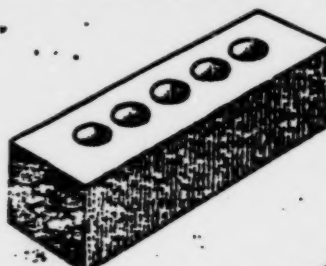
IV. ATLAS BRICK (ASTM C652) Compression Strength, PSI

Brick	Strength of Units NET AREA	Average Strength of Assemblages of Units & Mortar by Assumption from ICBO-R.R. 2730 Net Area in Pounds Per Sq. In.	Average Strength of Assemblages of Units & Mortar by Actual Prism Test 28 Days Net Area	
			Hollow	Grouted
Mountain Red & Brown Colors	11,000 (Average will vary from 10,000-13,000)	4300	6100	5600
Tiffany & Light Colors	8400 (Average 7500-8500)	3300	4300	5000

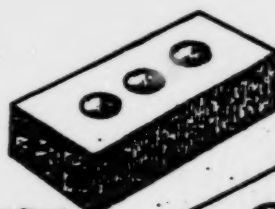
NOTE: FOR ATLAS BRICK ABSORPTION, ETC., SAME AS STANDARDS IN NO. 1

Basic Shapes

NOTE — Dimensions are listed as width x height x length.

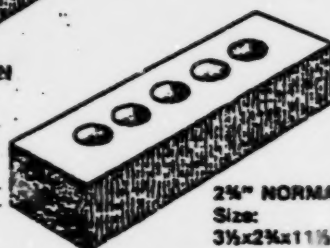
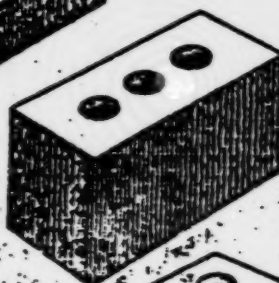


3W" NORMAN
Size:
3½x3½x11½

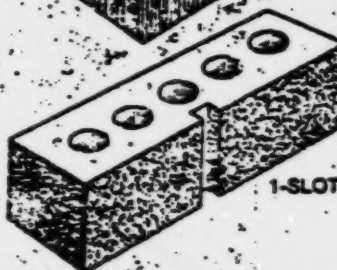


JUMBO
Size:
3½x4½x8½

(Actual Sizes)
STANDARD & MODULAR
Standard Size:
3½x2½x8½
Modular Size:
3½x2½x7½



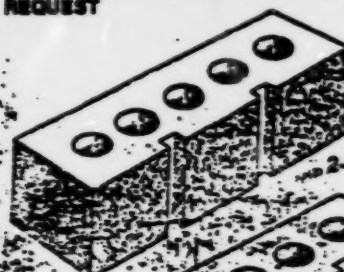
2W" NORMAN
Size:
3½x2½x11½



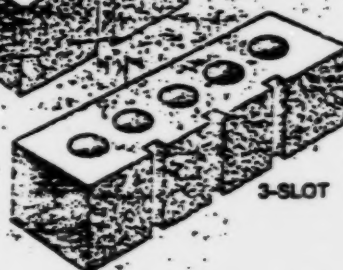
1-SLOT

Slotted Brick Specialties

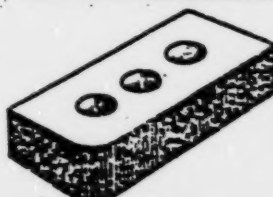
(Shown in 3W" Norman size. Also available in standard, modular, Atlas, etc.) For special Architectural effects (no extra charge). OTHER SPECIAL SIZES AVAILABLE ON REQUEST



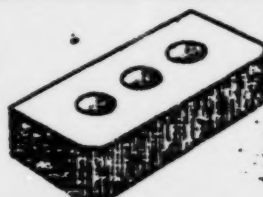
2-SLOT



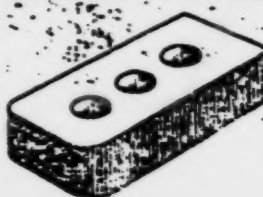
3-SLOT



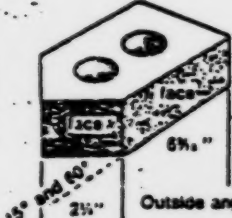
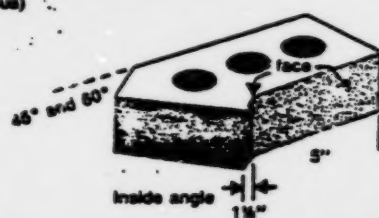
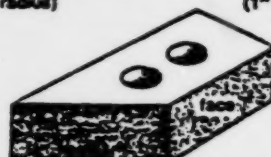
SINGLE BULLNOSE
(1" radius)



DOUBLE BULLNOSE
(1" radius)



DOUBLE END BULLNOSE (2 face)
(1" radius)



Length of face (or back) determined by angle cut.
Cut to any angle on special request.

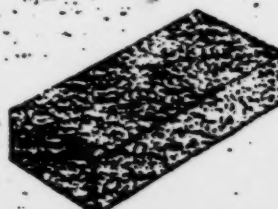
BULLNOSE AND ANGLES

(Shown in Standard size and also available in modular, Norman, etc.)

Interstate Floor Brick/Pavers

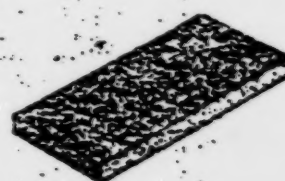
NOTE: 1" split paver to be set in mortar bed with 3/8" joints. True paver can be set in sand base with no joint. Paver sizes are intended for use with 4" Module and are adaptable for most standard architectural and landscaping patterns.

Interstate paving materials are intended for use where low absorption (less than 5%) is not required but generally will conform to requirements of ASTM 410 (type T & H) as per Pittsburgh Testing Laboratory Reports. Contact Interstate Brick for applicable specification needs and requirements if necessary. Other sizes and shapes available on request.



MODULAR BRICK PAVER
Mott (grain) texture only
3½x2½x7½

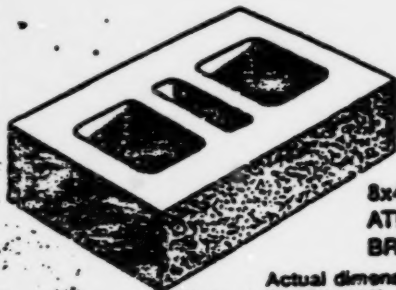
TRUE PAVER
4x2½x8



MODULAR BRICK PAVER —
SPLIT
Mott (grain) texture only
3½x1x7½

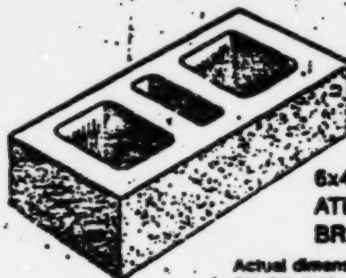
Atlas Brick

for the complete wall



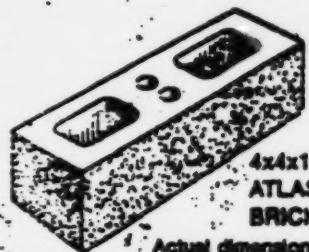
8x12
ATLAS
BRICK

Actual dimensions
7 1/2 x 3 1/2 x 11 1/2



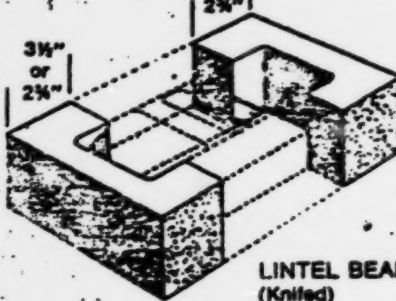
6x12
ATLAS
BRICK

Actual dimensions
5 1/2 x 3 1/2 x 11 1/2

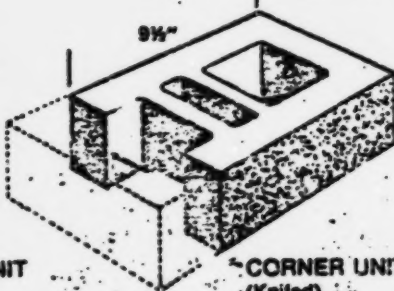


4x12
ATLAS
BRICK

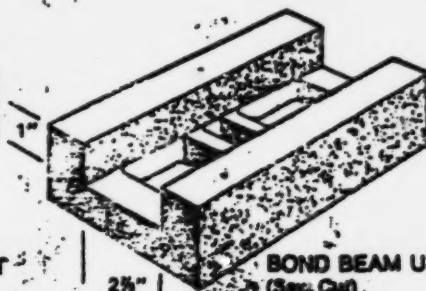
Actual dimensions
3 1/2 x 3 1/2 x 11 1/2



LINTEL BEAM UNIT
(Knifed)



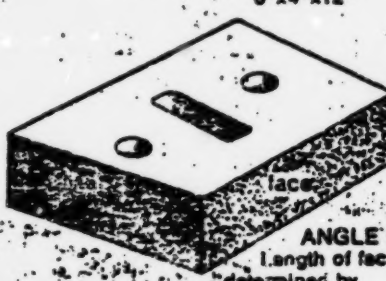
CORNER UNIT
(Knifed)
Available in these sizes only
4" x 4" x 12"
8" x 4" x 12"



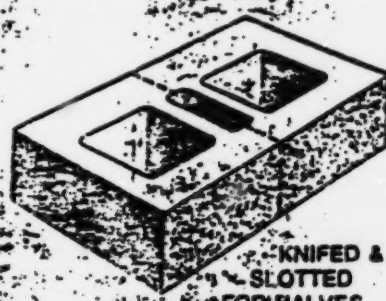
BOND BEAM UNIT
(Saw Cut)



BULLNOSE
1" radius available
also in double bullnose
and double-end bullnose



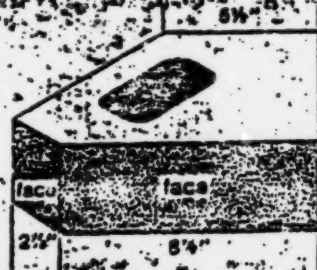
ANGLE UNIT
Length of face
determined by
angle cut.
Cut to any angle on special request.



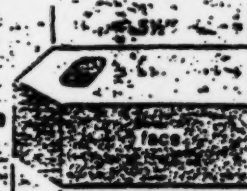
KNIFED &
SLOTTED
FOR HALVES



RADIUS ATLAS



ANGLE
UNIT



4x12
ATLAS
& 3 1/2"
NORMAN



6x12
ATLAS

NOTE:
Atlas brick are
available upon request
selected for 2-face exposure.
See additional price in
pricing schedule.
All units knifed for special.

Contact Interstate Brick
to confirm your radius
requirements.

B. Globe Refractories Inc.,
Newell, West Virginia

October 14, 1982

Contacts:

1. Mr. Syd Porter, V.P.
2. Mr. Robert Moore, Manager Technical Services

C. E. GLOBE REFRACTORIES INC.

NEWELL, WEST VIRGINIA

Globe Refractories Inc., a wholly owned subsidiary of Combustion Engineering Inc., is a major supplier of pouring pit refractories to the Steel Industry. Globe's product line includes ladle brick, sleeves, nozzles and pocket block.

Globe's operations are located in Newell, West Virginia and include underground clay mining, grinding facilities, pressing operations and tunnel kiln firing. The majority of the 300,000 tons of clay and bauxite raw materials processed annually are mined adjacent to the manufacturing facility. The grinding operation consists of two rim discharge grinders, 8 vibratory screens and materials distribution system utilizing 45 rubber belt conveyors. Products are formed on 10 mechanical presses, 3 hydraulic presses and/or a vacuum extruder. All products are fired in four tunnel kilns.

Research programs to find solutions to environmental control problems at Globe began in 1972. To date, Globe Refractories has spent \$4.5 million on research and equipment purchases for dust removal and air and water pollution control. The three specific areas where major expenditures have been made are:-

- (1) a dust collector to eliminate the dusting conditions in the grinding facilities, (2) an acid mine discharge treatment facility to treat acid mine water and scrubber liquor, and (3) an air pollution control system to clean the gases emitted from the four tunnel kilns.

In September 1977, Globe started operation of it's Number 1 Air Pollution Control System. This system incorporates a Celicote Ionizing Wet Scrubber (IWS). The IWS cleans the exhaust gases from two of the tunnel kilns. The system is designed to absorb hydrogen fluoride, hydrogen chloride and other soluble gases as well as to remove fine particulates.

Gases from the tunnel kilns contain ammonia and sulphur dioxide which react when cooled together to form ammonium bi-sulphate fume. This fume is submicronic and produces a blue-white haze. Because submicron particles have high reflectance, stack opacity requirements were extremely difficult to meet. The presence of HF and HCl in the gas stream made selection of materials for the air pollution control unit extremely critical since these acid gases severely corrode most materials of construction. The IWS system has been able to solve both submicron particulate collection and corrosion problems.

The IWS system functions in the following manner (Fig.1). Flue gases are collected from the two tunnel kilns and conveyed via ductwork to a quench unit. The quench through adiabatic cooling reduces the temperature of the flue gases from 400°F to saturation temperature of 140°F. The cooled flue gases emerge from the quench and go directly to a pre-scrubber which also serves as a gas cooler. The purpose of the pre-scrubber is to remove large particles, 5 microns and larger, and to further reduce the temperature to approximately 100-115°F to promote the formation of ammonium bi-sulphate. From the pre-scrubber,

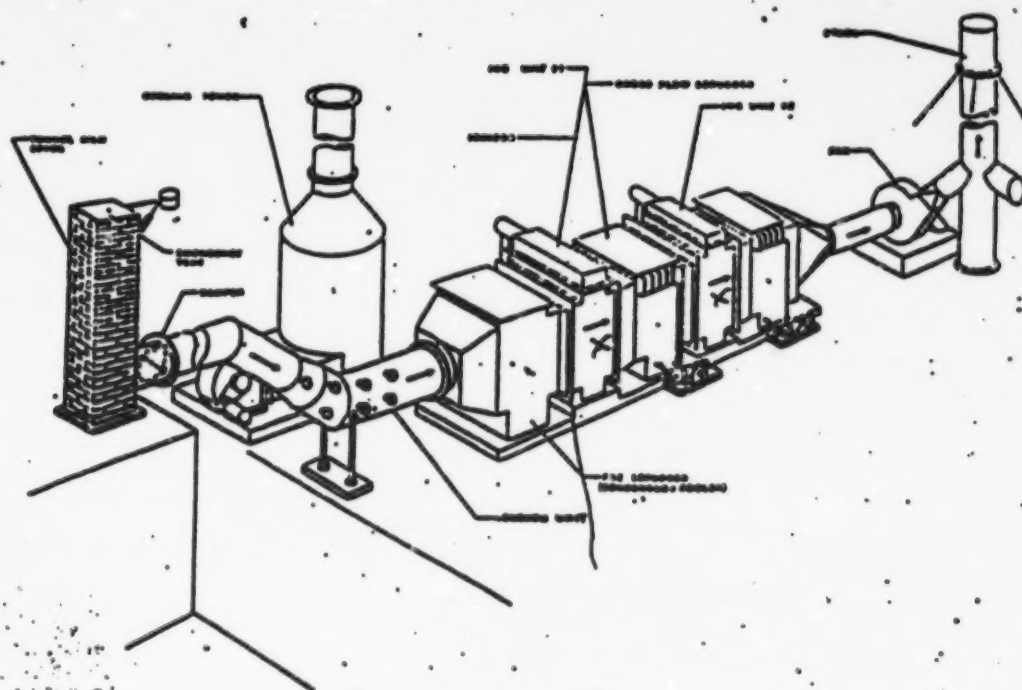


FIG. 1

PRESCRUBBER COOLER

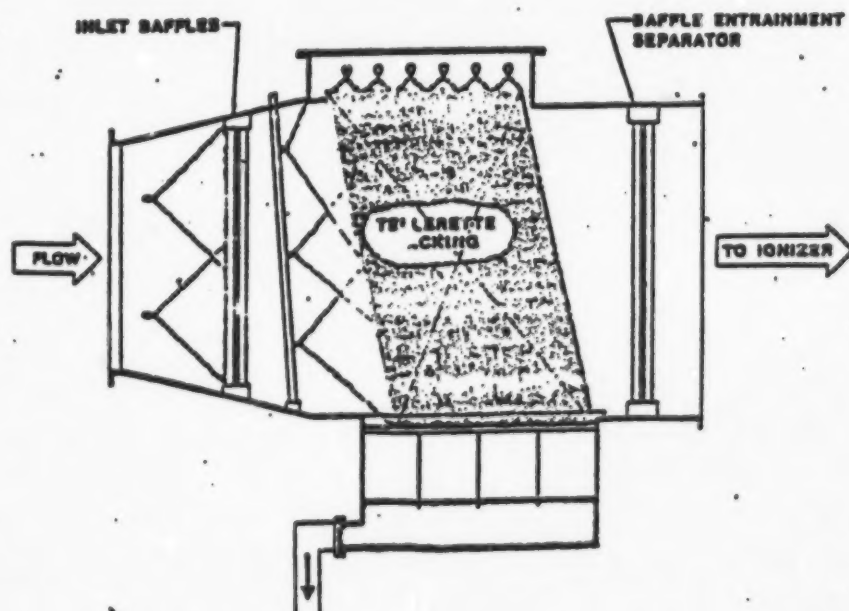


FIG. 2

From the pre-scrubber, the cooled and partially cleaned gases go to the first of two IWS units. The IWS units consists of a high voltage ionizing section and a wet scrubbing section. As the gases pass through the IWS unit, submicron particulate as well as soluble and reactive gases are removed. Upon leaving the first IWS unit, the flue gases enter a second IWS Unit where the cleaning process is continued. After leaving the second IWS unit, the clean gases are exhausted to the atmosphere through an FRP (fiberglass reinforced plastic) fan and stack. Details of the construction and operation of each component in the air pollution control system are as follows:

1. Ducting

Duracor fiberglass reinforced plastic (FRP) ducting conveys the flue gases from two existing chimneys to the IWS system. This duct is 5 ft. in diameter by approximately 100 ft. in length. A fail safe emergency by-pass vent is included to vent the gases directly to the atmosphere in the event of a system failure. The duct also contains a butterfly damper to isolate all downstream equipment, in case of an emergency. The damper is operated in conjunction with the emergency by-pass vent so it will close when the by-pass vent opens.

2. Quench

From the ducting, the gases enter the quench unit where they are cooled from approximately 400°F to 140°F, by evaporative cooling. The quench unit is constructed of FRP. It is of horizontal design, 7 ft. in diameter and approximately 9 ft. long. The spray pipes are made of Duracor FRP with silicon carbide nozzles. A horizontal centrifugal pump provides 100 IGPM of quench water at 120 ft of head.

3. Pre-Scrubber

The gas then enters a pre-scrubber (Fig.2) where the gas stream temperature is reduced to 115°F. In the pre-scrubber, the larger particles (5 microns and larger) are removed from the gas stream and soluble gases such as HF and HCl are absorbed. Ammonium bi-sulphate submicron particulate is formed from the gas phase reaction of ammonia and sulphur dioxide as the temperature is reduced. The pre-scrubber is a cross-flow design with a horizontal gas flow. The cross-sectional gas flow area is 10 ft by 10 ft. The overall length is 18 ft. The inlet has staggered baffles followed by a 6 ft. deep bed of Tellerette Tower Packing. The outlet has staggered channel baffles for entrainment separation. There are continuous water sprays on the inlet baffles, packing front face and above the packing bed. Water is recycled from a large settling pond for this purpose. Water for most of the sprays above the Tellerette Tower Packing is, however, first cooled in a cooling tower. The outlet baffles are flushed on a periodic basis with water.

4. COOLING TOWER

In order to cool the liquid to the pre-scrubber, a vertical counter-current FRP cooling tower was included in the IWS system. It cools the pre-scrubber water from 120°F to 85°F. The tower handles 720 IGPM with a cooling capacity of 15,000,000 BTU/hour. The tower is 12.5 ft. in diameter and approximately 21.5 ft. high. The main packed bed section contains 4 ft of 2" Tellerette Type-R Packing. The tower is topped with a stack to give an overall discharge height of 36 ft. above ground level.

A centrifugal fan supplies cooling air to a bottom side inlet in the tower. The fan is designed for 58,000 CFM at a 4" static pressure. A horizontal centrifugal pump pumps the cooled water to the pre-scrubber at a rate of 700 IGPM at a 60 ft. head. The pump which supplies water from the settling pond to both the pre-scrubber and cooling tower has a capacity of 1750 IGPM at a 75 ft. head. (Fig 3).

5. IONIZING WET SCRUBBER (IWS)

Upon leaving the pre-scrubber, the gases flow to a two-stage Celicote Ionizing Wet Scrubber for submicron particulate removal of soluble and reactive gases. The IWS unit is designed to remove solid and/or liquid particulates down to 0.05 microns. A high voltage ionizer is used to charge the particles in the gas stream before the gases enter a packed scrubbing section. The submicron particles are then removed by conventional inertial impaction and by image force attraction in the scrubbing section. Image force attraction occurs when an electrostatically charged particle comes within the boundary larger (usually within one millimeter) of a neutral surface.

Under these conditions, the charged particle is drawn to and is captured on the surface of the Tellerette Tower Packing. The force of attraction is equivalent to that which would exist between a charged particle and an imaginary particle of equal but opposite polarity located at an equal distance behind the neutral surface. It is as though the charged particle sees it's mirror image (Fig. 4)

The ionizer module is constructed of Dracor FRP and is a wetbed wall design with water distributed over the grounded

FIG. 3

CHARGED PARTICLE

"IMAGE FORCE" ATTRACTION

INDUCED SURFACE CHARGES

NEUTRAL SURFACE

"MIRROR IMAGE" OF CHARGED PARTICLE

FIG.4

plate surfaces. There is an additional deluge flushing system provided to allow periodic complete flushing of the entire ionizer. The grounded plates and charging wires along with a few other require metal components in contact with the gas stream are constructed of Hastelloy C276 alloy for maximum corrosion resistance. Two alloy electrode wires are mounted vertically between each pair of grounded plates. Power is furnished by a high voltage transformer/rectifier. (Fig.5);

The first ionizer unit operates at 30,000 volts with a current of 100-110 milliamps. The second unit operates at 31,500 volts with a current of 210-225 milliamps.

After passing through the ionizer section where the fine particles are charged, the gas stream enters a Celicote FRP packed crossflow scrubber module. The scrubber contains 4 ft. of irrigated 2" Tellerette Type-R Tower Packing and 1 ft. of unirrigated packing for liquid entrainment separation. The unit includes horizontal top sprays for Tellerette Packing irrigation and vertical front sprays for washing the front packing face. There is an additional spray header above the liquid entrainment separation zone. This spray header automatically flushes the normally unirrigated Tellerette Tower Packing of the entrainment separation zone on a periodic basis. The recirculation pump supplying the top and front sprays has a capacity of 480 GPM at a head of 50-60 ft.

After leaving the first IWS unit, the gas stream passes through the second IWS unit where additional submicron particles and noxious gases are removed.

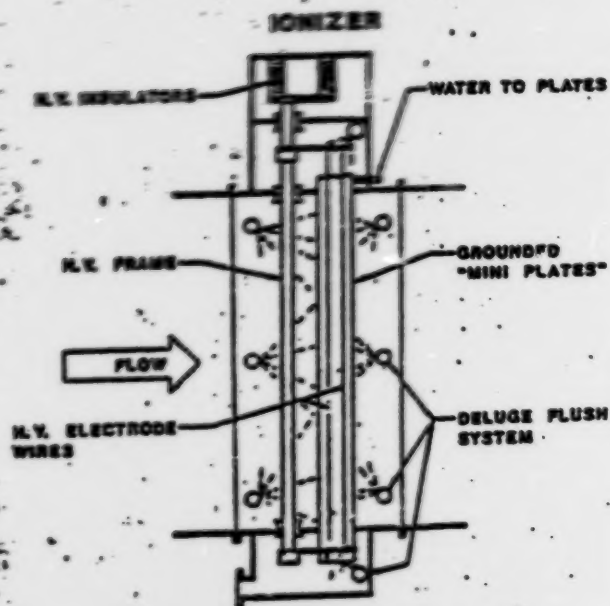


FIG.5

6. Fan and Stack

The scrubbed gas stream flows into a 48" duct approximately 20 ft. long which is connected to a Plastic Blower Company 48" centrifugal fan. The duct is fitted with straightening vanes and has the 3" sampling ports. There is a flexible connection between the duct and the fan inlet.

The centrifugal fan is of fiberglass reinforced polyester construction with a capacity of 42,000 CFM at 115°F saturated and 11" static pressure. The gas stream is exhausted to the atmosphere through a Celicote FRP stack 66" diameter and 150 ft height.

POTENTIAL FOR FLY ASH CONTROL

Globe Refractories has experimented with pulverized coal firing on one of it's tunnel kilns. The currently installed air pollution control system has been designed for fly ash removal if the tunnel kilns are converted to pulverized coal firing.

This is the first Celicote Ionizing Wet Scrubber system that has been designed to incorporate a pre-scrubber which serves as a gas cooler and is capable of both large particle fly ash and noxious gas removal.

The initial design of the system did not include provisions for fly ash and called for a quench unit to be located at the tunnel kiln stack in order to reduce the stack gas temperature from 450°-140°F. This was believed to be necessary to protect the FRP ductwork which connects the tunnel kiln stack to the scrubber system from heat damage. Extensive pilot plant studies were conducted at Globe where fly ash was introduced at the quench unit and conveyed through a long duct

to the pre-scrubber. Unfortunately wet ash accumulated and built up on the walls of the duct to such an extent that, in order to keep the duct free of build up, it was decided that the quench unit had to be relocated adjacent to the pre-scrubber. The original design was changed to utilize a cross flow scrubber. This simple piece of equipment could both cool the gas stream and also handle the heavy solids loadings.

Pilot plant studies were then conducted by substituting a modified Celicote cross-flow scrubber system as a pre-scrubber. Large quantities of fly ash in the gas stream were introduced into the Celicote cross flow scrubber system with excellent ash removal and no buildup or plugging.

Pilot tests also verified that the crossflow scrubber was very efficient as a condensor/cooler and provided the desired temperature drop (140° down to 115°F) required to promote the reaction of ammonia and sulphur dioxide to form the ammonium bi-sulphate particulate.

Based on these tests the following modifications were made to the initial design of the air pollution equipment to accomodate the added requirements of coal firing:

- a) The quench unit was relocated next to the pre-scrubber. A special high temperature resistant reinforced plastic was used in the ducting from the kiln stack. Safety controls were added including temperature controls to open the emergency by-pass dampers on the kiln stacks to insure that the temperature in the duct work never exceeds 450°F .
- b) The pre-scrubber was redesigned to the crossflow made with inlet baffles, once through water and a sloped bottom.
- c) Large settling ponds were added to remove the fly ash from the

scrubber water. The settling ponds also reduce the suspended solids to acceptable levels in order to avoid excessive erosion of FRP piping, scrubber nozzles and recirculating pumps.

d) The addition of the ponds necessitated a revised liquid recirculation system. Pumps were relocated to the pond location in a pump house which provides flooded pump suction. An additional pump was added for increased liquid circulation requirements. Because of the added solids content in the recycled water, an automatic flushing system was added to the entrainment separation zone of the cooling tower.

TEST RESULTS

Start up of the Number 1 Air Pollution Control System began in September 1977. Performance tests were conducted on November 21 and 22. The results of those tests are summarized as follows: Table 1 lists inlet and outlet readings for particulate. The average of 6 tested indicated an 87% removal efficiency.

TABLE 1 - PARTICULATE

	<u>INLET</u>	<u>OUTLET</u>	<u>% REMOVAL</u>
lbs/hour	21	2.7	87%
Gr/DS CF	.068	.998	
mg/Nm ³	156	18.3	

In order to put this information in better perspective, Table 2 compares these particulate test results to the performance of the IWS as projected from the pilot test data, performance guaranteed by the Celicote Company and the State of West Virginia code requirements. Actual particulate discharge is 13% less than predicted from pilot test data and 70% less than as guaranteed and 83% less than required by State code.

	Particulate	lbs/hour
a.	Pilot test projection	3.1
b.	Actual performance	2.7
c.	Celicote guarantee	8.9
d.	State Code	16

Estimates of opacity range from 10 to 15% of particular interest is the fact that, while a clear or "near clear" stack was not obtained, actual emissions of 0.008 Gr/DSCF were achieved. In many other industries, grain loadings of more than twice this level do result in a clear or "near clear" stack. This is indicative of the unusually fine particle size associated with the refractory kiln discharge. Table 3 illustrates the grain load emissions among various industries necessary to achieve a "clear stack" emission.

TABLE 3 - EMISSION LEVELS FOR CLEAR OR "NEAR CLEAR" STACKS

<u>Process</u>	<u>Gr/DSCF</u>
Pulverized Coal Boiler	0.030
Kraft Recovery Boiler	0.041
Cement Kiln	0.028
Basic Oxygen Furnace	0.021
Zinc Smelter	0.017
Municipal Incinerator	0.034
* Globe Refractories	0.008

HCl removal results are summarized in Table 4. As indicated by an average of 6 inlet and outlet tests, HCl removal efficiency exceeded 99%.

TABLE 4 - HCl

	<u>INLET</u>	<u>OUTLET</u>	<u>% EFFICIENCY</u>
lbs/hour	49	.44	99+
Gr/DSCF	.160	.001	
ppm	243	2	

As was the case with HCl, HF removal efficiency was better than 99%.

TABLE 5 - HF

	<u>INLET</u>	<u>OUTLET</u>	<u>% EFFICIENCY</u>
lbs/hour	7	.03	99+
Gr/DSCF	.023	.0001	
ppm	64	.3	

NOx removal is summarized in Table 6. The better than 75% removal achieved was somewhat unexpected. Nox absorption of this magnitude could only be explained by the fact that the gas stream is subjected to four scrubbing processes in series, namely, the quench, the pre-scrubber, and the two IWS scrubbers.

TABLE 6 - NOx

	<u>INLET</u>	<u>OUTLET</u>	<u>% REMOVAL</u>
lbs/hour	51	25	51%
Gr/DSCF	.164	.076	
ppm	142	71	

The cost of the Number 1 Air Pollution Control system was \$1,430,000 (U.S.). The second system installed in 1978 cost \$1,100,000 (US).

STACK EMISSIONS FROM PLANTS WHICH PRODUCE
BLOATING LADLE REFRACTORY PRODUCTS

INTRODUCTION

There are four major suppliers of bloating-type ladle refractories in the United States. The suppliers are Globe, Freeport-Kittanning, Resco, & Swank; and the manufacturing plants are located in Ohio, Pennsylvania and West Virginia. The refractory products include ladle brick, sleeves, nozzles, and pocket block; and these products are used to line iron and steel ladles in the steel industry. The major product is ladle brick, and the bloating-type brick is the most economic for the customer. Ladle brick are cheaper to manufacture due to the top firing temperature of around 2000⁰F., which is a low temperature compared with other refractories. The term bloating is used to designate a class of refractories, which has a permanent expansion when reheated to either 2350⁰F or 2460⁰F as specified using ASTM C-8 tests.

COMPOSITION OF GLOBE CLAY

Globe and most of its competitors use what is called Lower Kittanning clay. This clay is composed mainly of the minerals Kaolinite, Quartz, Illite, and Pyrite. The minor constituents include organic matter, micas, and ammonium chlorides or fluorides.

REACTIONS WHICH OCCUR DURING FIRING

The reactions which take place during firing include oxidation of carbon to form carbon dioxide, oxidation of pyrite to form iron oxide and either sulfur dioxide or sulfur trioxide, decomposition of the hydrated alumino silicates (Kaolinite and Illite) to release chemically combined water, decomposition of ammonium chloride (or fluoride) to form gases of ammonia or fluorine, and the fluxing action of the alkalis which forms the glass which bonds the brick and is called the ceramic bond.

PERIODIC KILN FIRING VS. TUNNEL KILN FIRING

The early production of bloating refractories was all fired in periodic kilns, but today it is more economical to fire in tunnel kilns due to firing costs and productivity. Globe no longer uses periodic kilns, but all of our competition still use periodic or shuttle kilns. The periodic kiln is a batch type furnace where the ware is stationary and the temperature is gradually increased until the top temperature is reached; then the temperature is put on hold until the temperature is reached; then the temperature is put on hold until the temperature of the lower part of the setting equalizes with the top. The only stack emission occurs during the temperature range of 1000[°]F to 1500[°]F., which is called the water smoking period, and this emission can last for one or two days. In the tunnel kiln fire, the ware is continuously moving through the kiln, but the temperatures of the different zones in the kiln are held constant. The stack emission from the tunnel kiln is continuous.

A normal firing cycle for a periodic kiln is from 8 to 15 days. This would mean that two to three times each month, the stack emissions would be highly visible for a 24 to 48 hour period, due to the water smoking. If an EPA observer read stacks only once per month, the stack emission period would be missed. Since the tunnel kiln is a continuous process, there is a constant stack emission. The normal firing cycle for a tunnel kiln is 4 to 6 days.

VARIATION OF STACK OPACITY

Stack opacities at Globe have been read by observers from the W. Va. EPA, and have ranged from 20% to 70%. The range is caused by variations in the clay raw material, production rate, and by weather conditions. It has been noticed that low humidity summer days show the least opacity, and high humidity winter days show the highest opacity.

GLOBE REFRACTORIES INC.

QUESTIONNAIRE

1. Continuous Tunnel Kilns

1. Swindell Dressler - 1967 - under deck fired
2. Swindell Dressler - 1970 - under deck fired
3. Allied - 1950 - side-fired
4. Harrop - 1925 - side-fired

2. Capacity

1. Swindell Dressler - 10.5 million Ladle Eq./year
2. Allied - 14.6 million Laddle eq./year
3. Harrop - 8.2 million Laddle Eq/year

3. Firing Temp. - 1950° - 2000°F

4. Total Hours through Kilns - 63 hrs.

5. Fuel - Natural Gas - 980 BTU/Ft³

3/3/79

GLOBE REFRACTORIES, INC.Product Technical Data - Globe Ladle Brick

<u>Physical Properties</u>	<u>Clay</u>
Bulk Density oz./in. ³ gm./cc.	1.26 - 1.32 2.18 - 2.28
Apparent Porosity %	11% - 17%
Reheat Expansion (2350°)	6% - 12%
P.C.E. (Cone)	20 - 26
Modules of Rupture (P.S.I.)	700 - 2300

Chemical Analysis (Approximate)

Silica (SiO ₂)	67.21
Alumina (Al ₂ O ₃)	26.07
Titania (TiO ₂)	1.31
Iron Oxide (Fe ₂ O ₃)	1.98
Lime (CaO)	.18
Magnesia (MgO)	.41
Alkalies (Na ₂ O + K ₂ O)	2.69

The data listed are typical for Globe products, but are not to be used for specification purposes.



PHOTO 1

This photo illustrates the 150 ft. exhaust stack and its plume originating from Globe Refractories, Newell West Virginia.

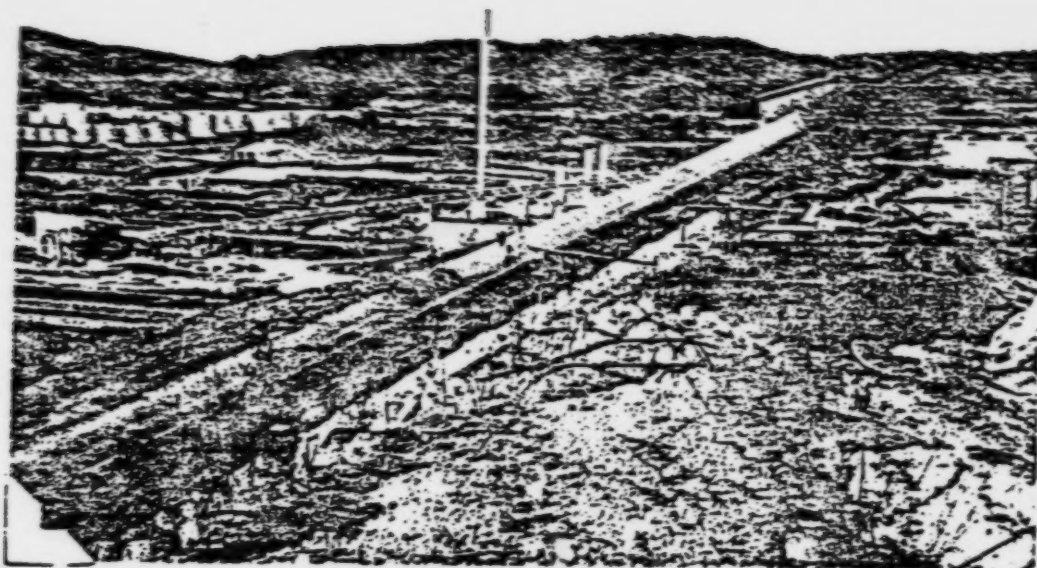


PHOTO 2

This photo represents another perspective of Photo1 showing the 150 ft. exhaust stack, and the two smaller 22 ft. cooling towers. Adjacent to Globe's plant is Quaker States oil refinery. Also seen in the background is the Ohio river and the hills of the state of Ohio (liverpool) on its bank.

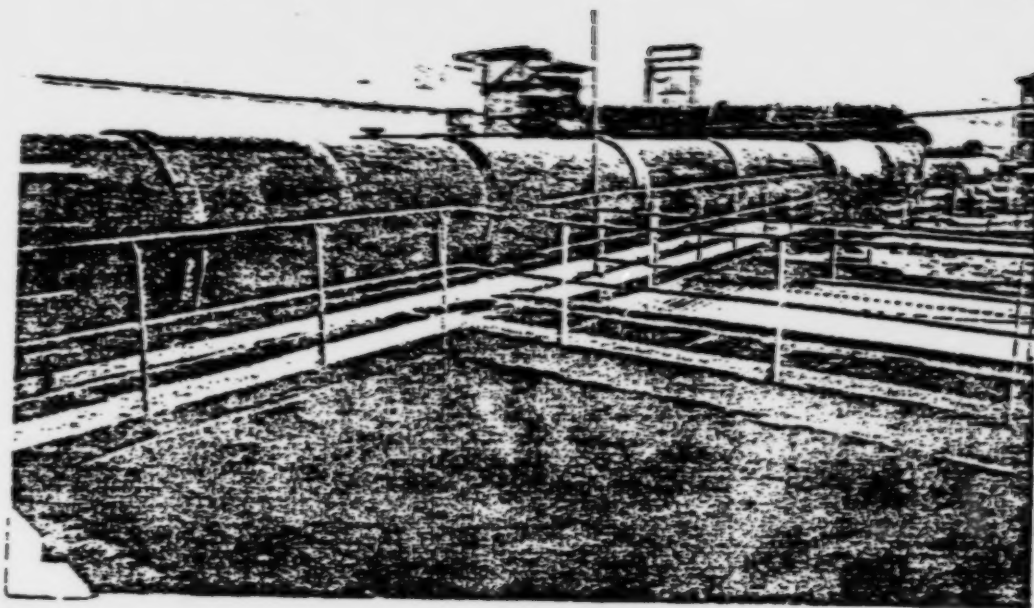


PHOTO 3

This photo shows the Duracor fiberglass reinforced plastic ducting from one of the tunnel kilns to the IWS control systems. Note the fail safe emergency by-pass vents.

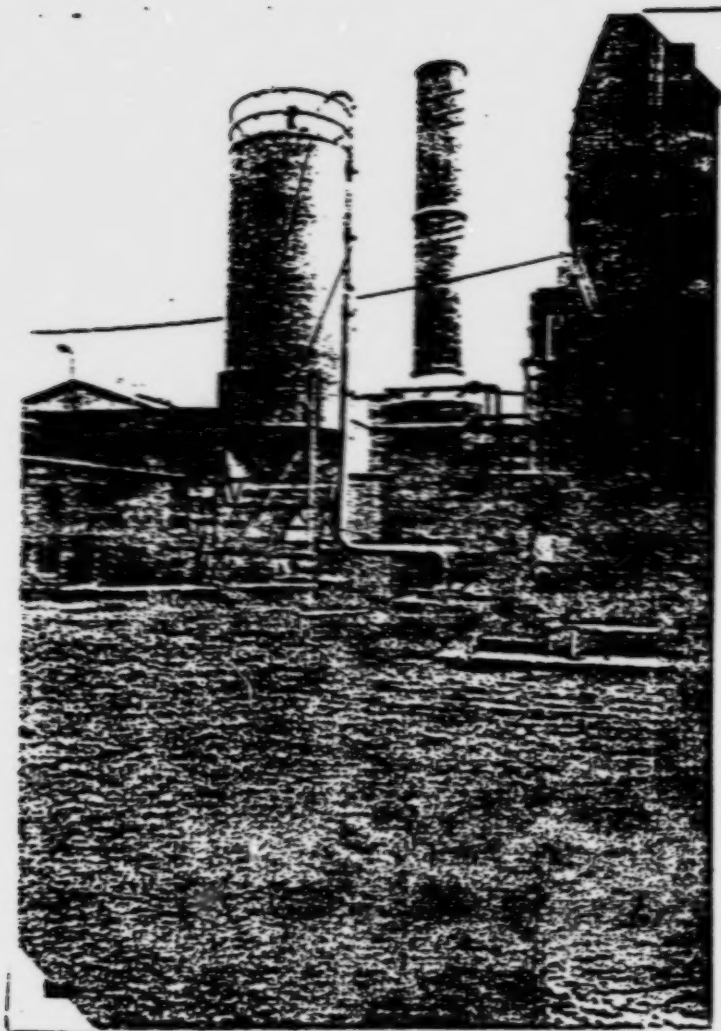


PHOTO 4

The 22 ft. FRP cooling tower is seen in this photo. To its left is a silo used to store soda ash dry. This soda ash is automatically added to the scrubber effluent to maintain a pH of 3.3-4.2 being discharged to the settling ponds.

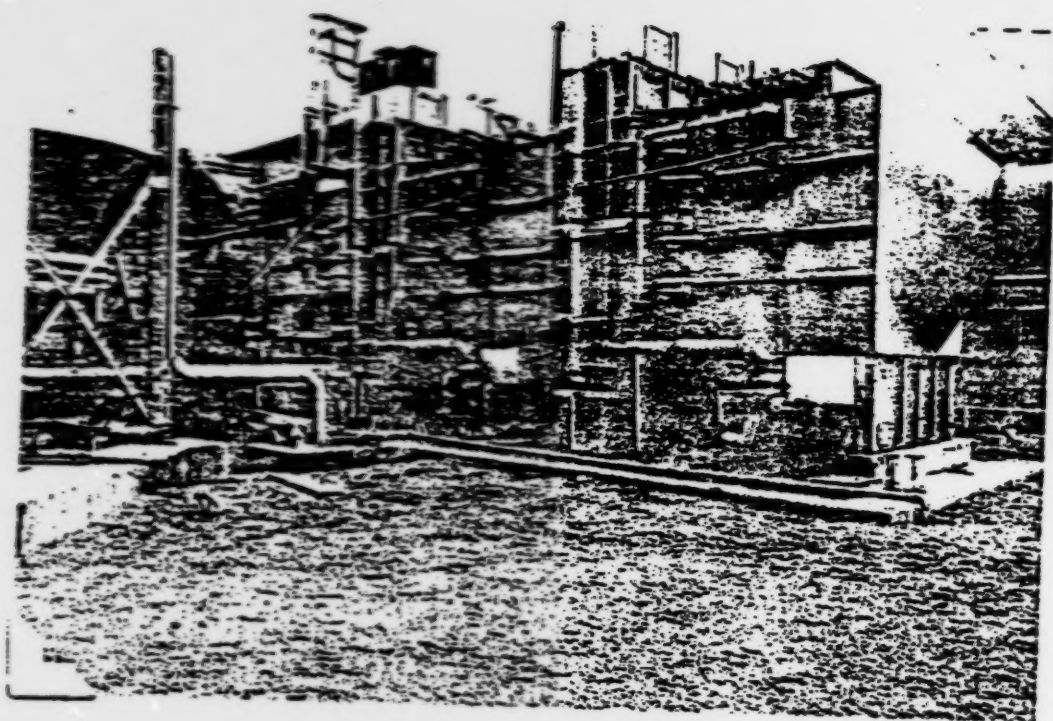


PHOTO 5

This photo illustrates (L to R) the pre-scrubber and the two Ionizing Wet Scrub er units.

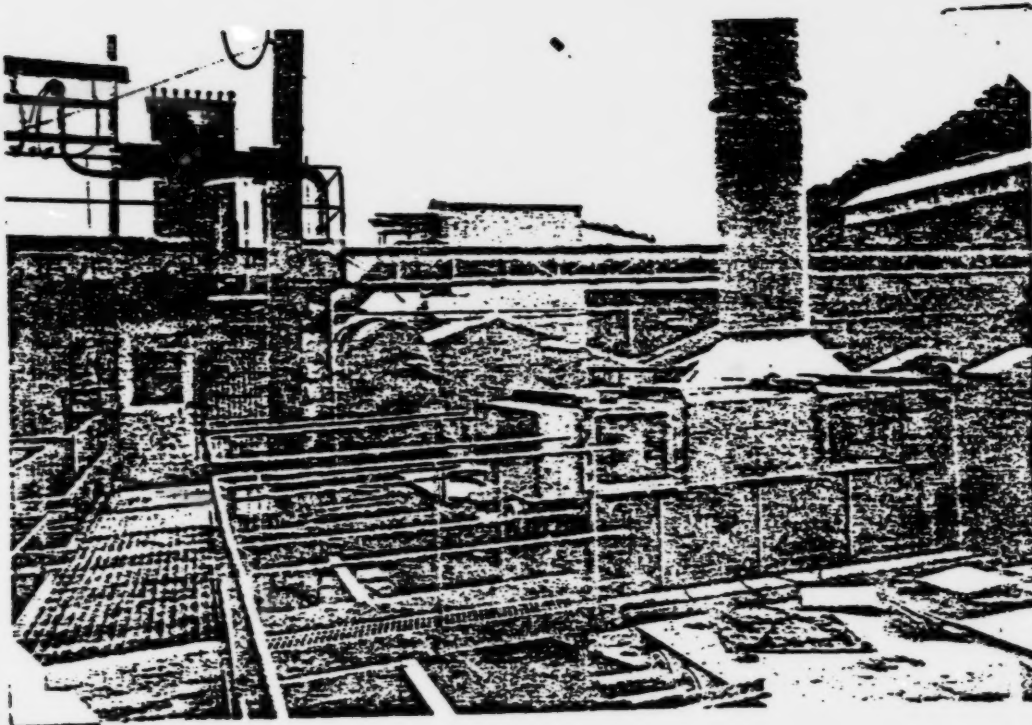


PHOTO 6

The #1 Ionizing Wet Scrubber unit can be seen in this photo. The cover of the unit has been removed for maintenance.

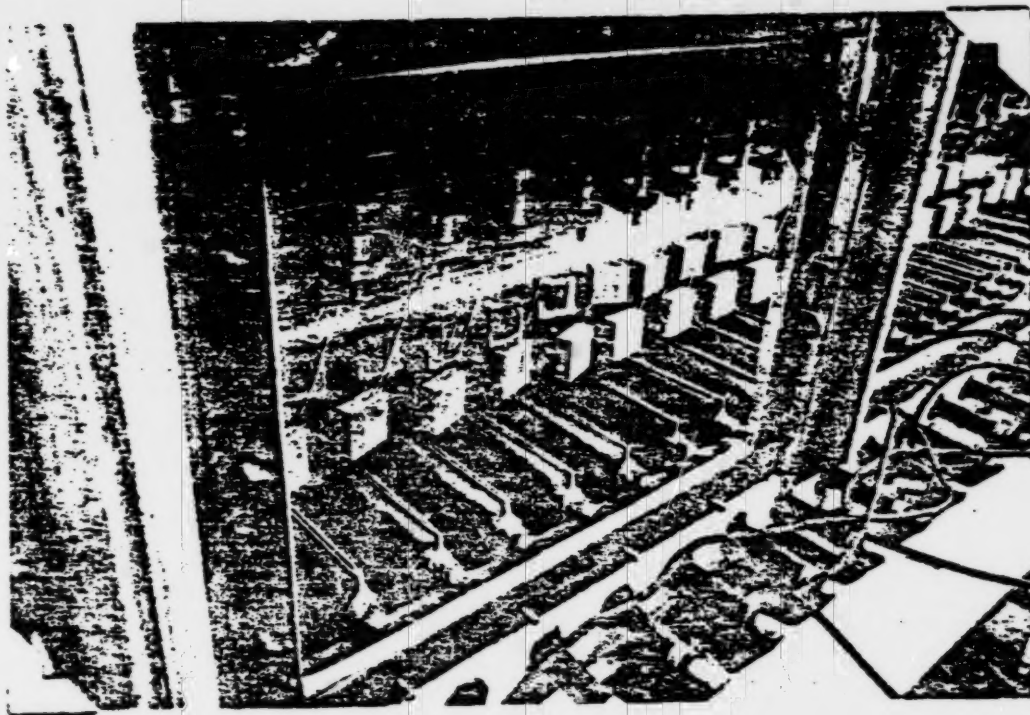


PHOTO 7

This photo illustrates the components of the #1 IWS unit. Note the paired ground plates and the charging wires.

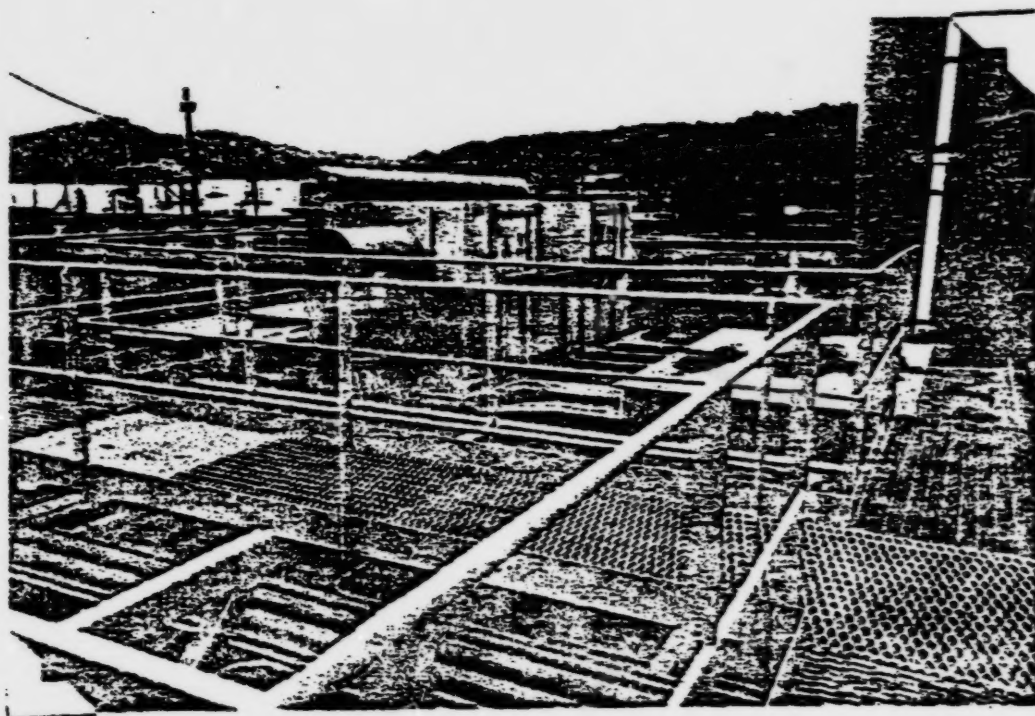


PHOTO 3

The #2 IWS unit is seen in this photo. At this time the entire pollution control system was operating except for the two IWS units.

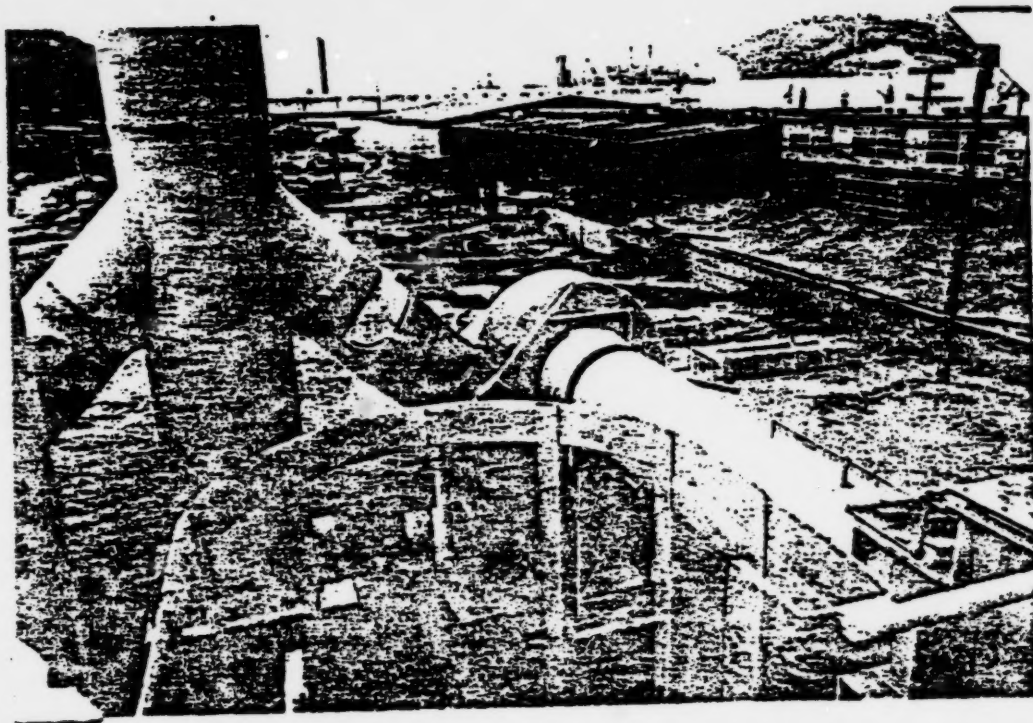


PHOTO 9

This photo illustrates the 20 ft. ducting which the scrubbed gas stream flows in to be directed toward the stack.

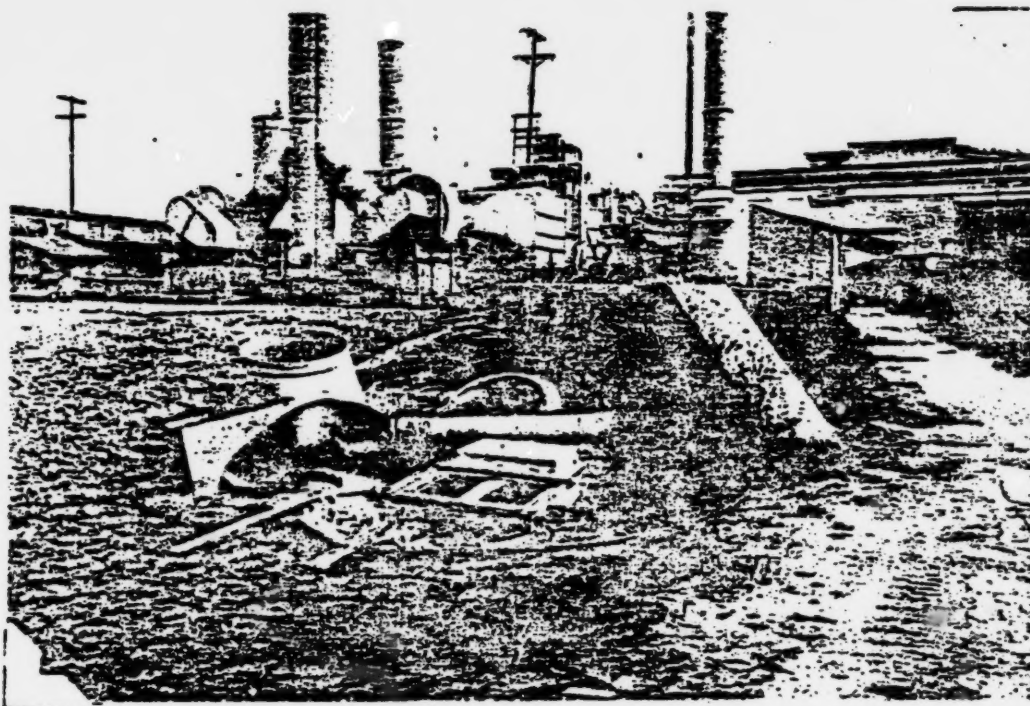


PHOTO 10

Another perspective of both air pollution control systems can be seen in this photo.

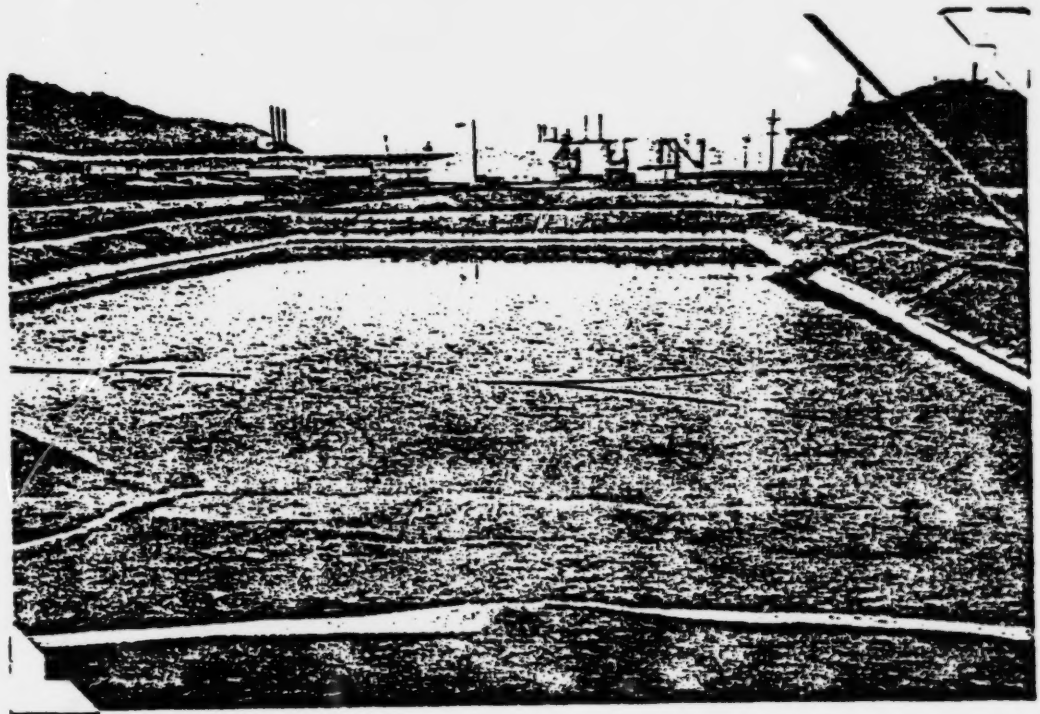


PHOTO 11

One of the 4 settling ponds is shown in this photo.
Each one is lined with a special blanket and has a
concrete base.

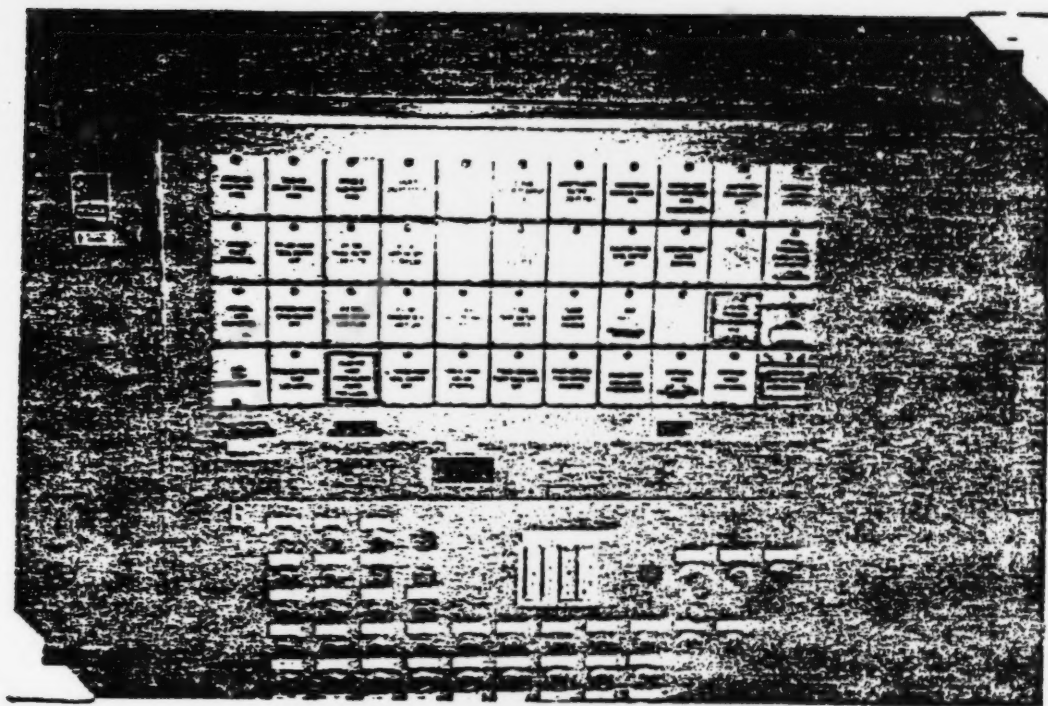
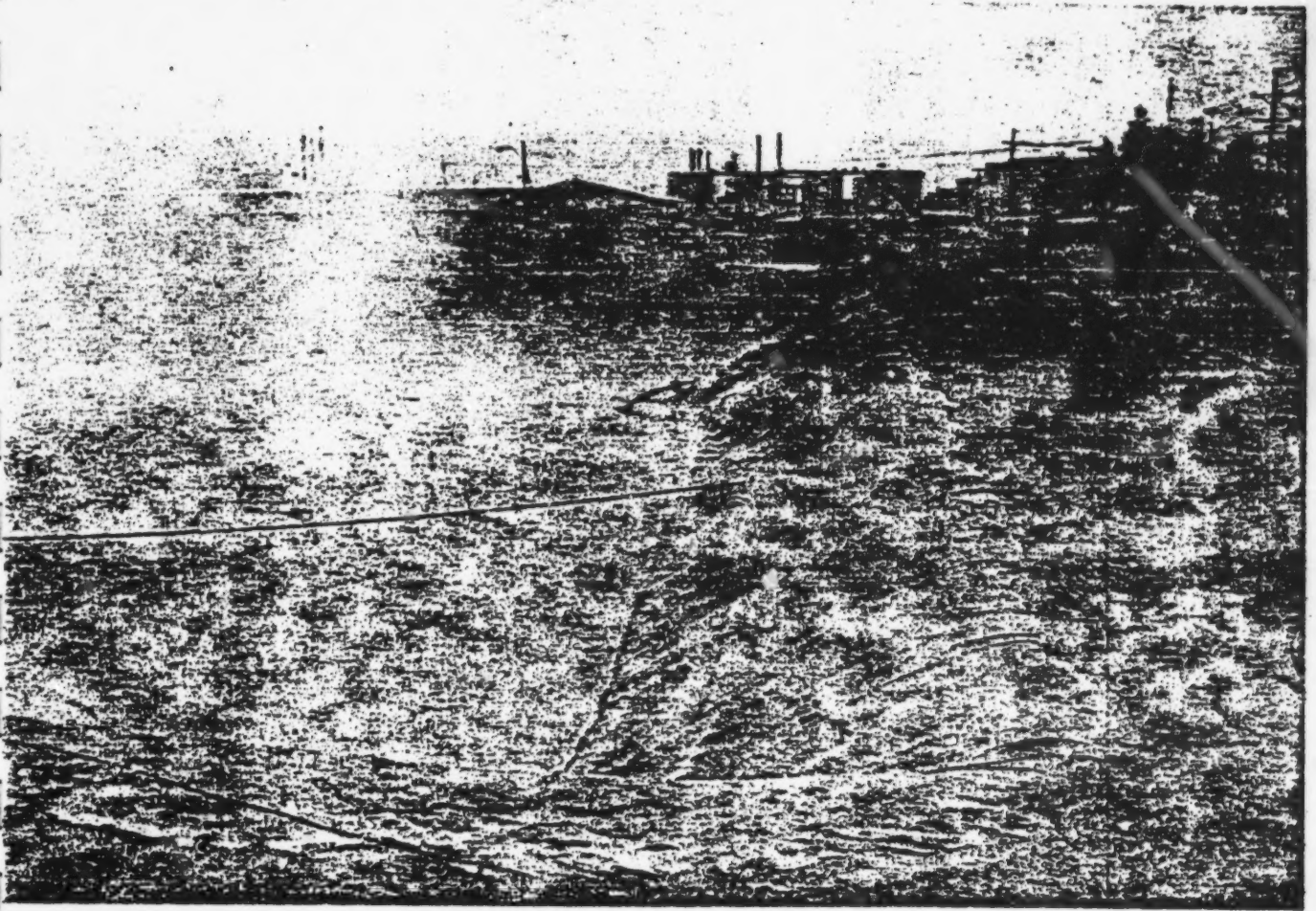


PHOTO 12

The entire system is automatically controlled from a central control room. This photo illustrates the control panel for one of the units.

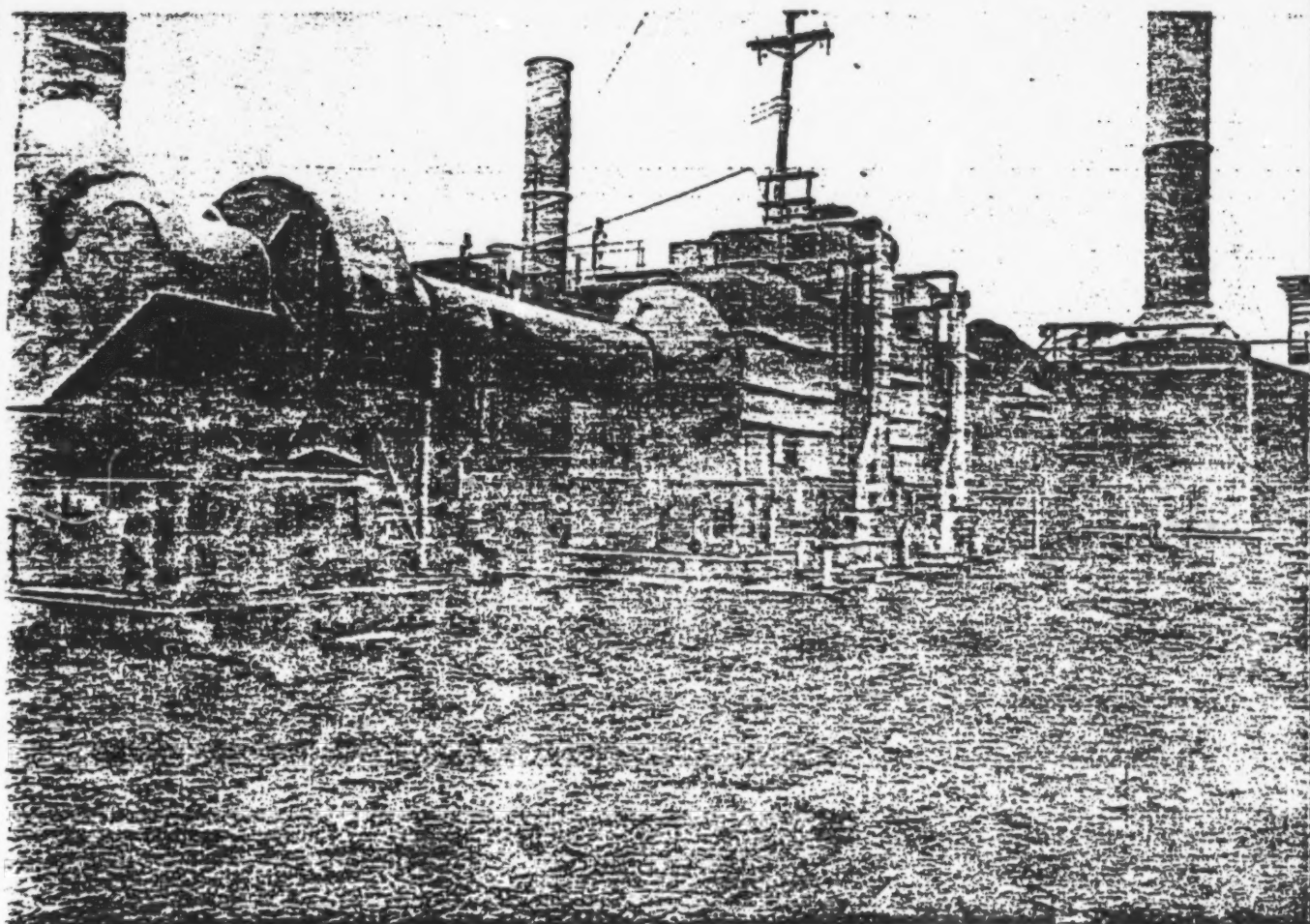


Settling pond used to recycle water from scrubber wash down.

Ionizing Wet Scrubber Keeps Globe Refractories In Compliance

Stringent state environmental laws required the cleaning of tunnel kiln flue gases. New system reduced particulate level 83% below required level. It took decision, persistence and lots of money.

By: P.E. Jeffers, Editor



Ionizing wet scrubber system consists of two stages of ionizers and scrubbers.

Although firing refractories in a tunnel kiln using natural gas would not seem to present a problem with air pollution, stack tests at Globe Refractories, Inc., a wholly owned subsidiary of Combustion Engineering, Inc., showed more particulate than was allowed for their Newell, West Virginia location. The blue and sometimes white smoke contained about 21 lbs. of particulate per hour—the state permitted 16 lbs. hr. This was in 1971, and an investigation began immediately to find a solution to the problem.

Globe Refractories processes about 300,000 tons of clay and bauxite raw materials annually, producing a product line that includes ladle brick, sleeves, nozzles and pocket block. All products are fired in four tunnel kilns. The plant is the most automated of its type in the refractories industry.

Additional stack tests confirmed the particulate problem and showed that sulfur dioxide was not a problem. Of major concern was the presence of a very corrosive submicron, condensable gas, most of which was ammonium bisulfate. A number of pilot plant studies were conducted, including bag filters, coated bag filters, ammonia injection, dry electrostatic precipitators, high-energy scrubbers and mist eliminators. None were found to be completely successful for various reasons such as excessive corrosion. All this had taken four years to complete.

Ionizing wet scrubber the solution

The next step, and the one that proved successful, was to install "a two stage ionizing wet scrubber system". Flue gases are collected from two tunnel kilns

and conveyed via ductwork to a quench unit. The quench, through adiabatic cooling, reduces the temperature from 400°F to saturation temperature of 140°F. The cooled flue gases emerge from the quench and go directly to a prescrubber which also serves as a gas cooler. The purpose of the prescrubber is to remove large particles, five microns and larger and to further reduce the temperature to approximately 100-115°F to promote the formation of ammonium bisulfate. From the prescrubber, the cooled and partially cleaned gases go to the first of two IWS (Ionizing Wet Scrubber) units.

"Ionizing Wet Scrubber system is a product of The Celicote Co., a unit of General Signal, Berea, Ohio.

"Globe has spent some \$4.5 million for pollution control"

The IWS units consist of a high voltage ionizing section and a wet scrubbing section. A high voltage ionizer is used to charge the particles in the gas stream before the gases enter a packed scrubbing section. The submicron particles are then removed by conventional inertial impaction and by image force attraction in the scrubbing section. Image force attraction occurs when an electrostatically charged particle comes within the boundary layer of a neutral surface.

The charged particle is drawn to and is captured on the surface of the tower packing. The force of the attraction is equivalent to that which would exist between a charged particle and an imaginary particle of equal, but opposite, polarity located at an equal distance behind the neutral surface.

Construction features of ionizer

The ionizer module is constructed out of fiber glass reinforced plastic (FRP) and is a wetted wall design with water distributed over the grounded plate surface. There is an additional deluge flushing system provided to allow periodic, complete, flushing of the entire ionizer. The grounded plates and charging wires, along with a few other required metal components in contact with the gas stream, are made of Hastelloy C-276 alloy for maximum corrosion resistance.

After passing through the ionizer section where the fine particulate is charged, the gas stream enters a FRP packed cross flow scrubber module. The unit includes horizontal top sprays and vertical front sprays for washing the packing face. An additional spray above

the liquid entrainment separation zone automatically flushes the unrigated tower packing on a periodic basis. After leaving the first IWS unit, the gas stream passes through the second IWS unit where additional submicron particles and noxious gases are removed. Tests at Globe, during the original investigation of their equipment, showed that one unit by itself was not successful. After leaving the second IWS unit, the clean gases are exhausted to the atmosphere through a FRP fan and stack. Acidic gases are absorbed by the scrubbing liquid. The particles are then washed into the liquid, and later stabilized for disposal.

System in preparation four years

Globe Refractories began preparation for the new system in February 1976, when eight periodic kilns were demolished to make room for construction. After delays, due to energy shortages that curtailed gas and forced stopgap measures such as burning oil and experimenting with coal, the first installation went into use September 1977. The second unit was completed in 1979.

Performance tests have shown that 87% of the particulate has been removed, i.e., from 21 lbs./hr. down to 2.7 lbs./hr. The state law permits 16 lbs./hr., so the results at Globe are 83% below state requirements for particulates. The actual results also were 13% below that predicted by a pilot test, and 70% below the guarantee from the equipment supplier.

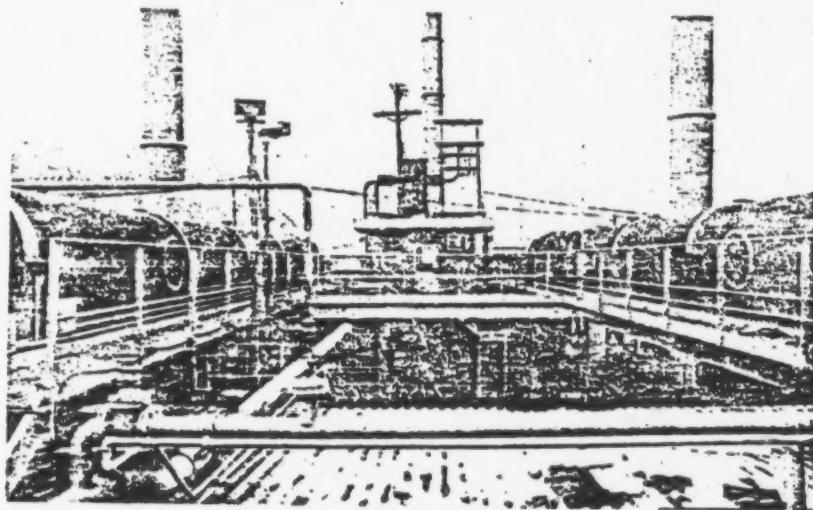
HCl, HF removal by the system exceeded 99%, NO_x removal was better than 75%, and SO₂ removal exceeded plant expectations.

Millions spent for pollution control

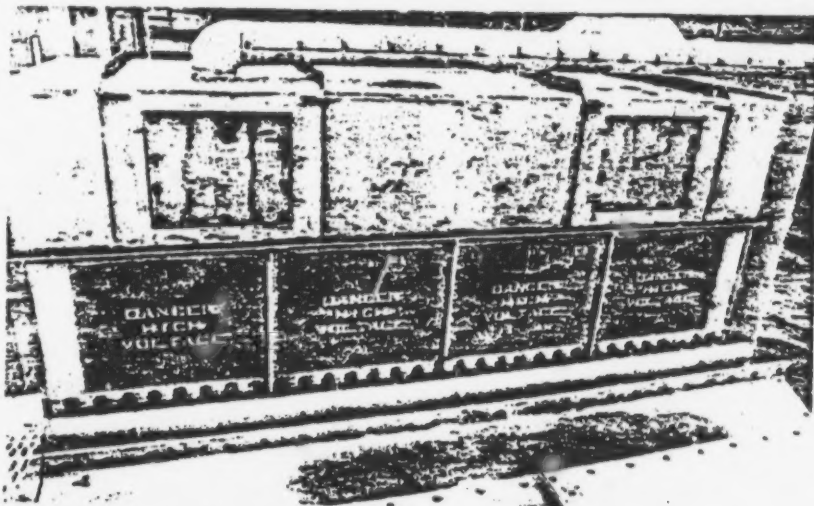
Globe Refractories, Inc. now is meeting all federal and state air pollution laws and has set an example for the entire refractories industry. They also have installed extensive dust control systems in the plant, and a sophisticated water pollution control plant to neutralize mine water drainage. In all, Globe has spent some \$4.5 million in the past 6-8 years for pollution control. It's a lot of money to spend on nonproductive equipment, but its one guarantee that they will be among those who will be permitted to operate through the 1980's.

Approximate Metric Equivalents

100°F—38°C
115°F—46°C
140°F—60°C
400°F—204°C
2.7 lb/hr—1.2 kg/hr
16 lb/hr—7.2 kg/hr
21 lb/hr—9.5 kg/hr

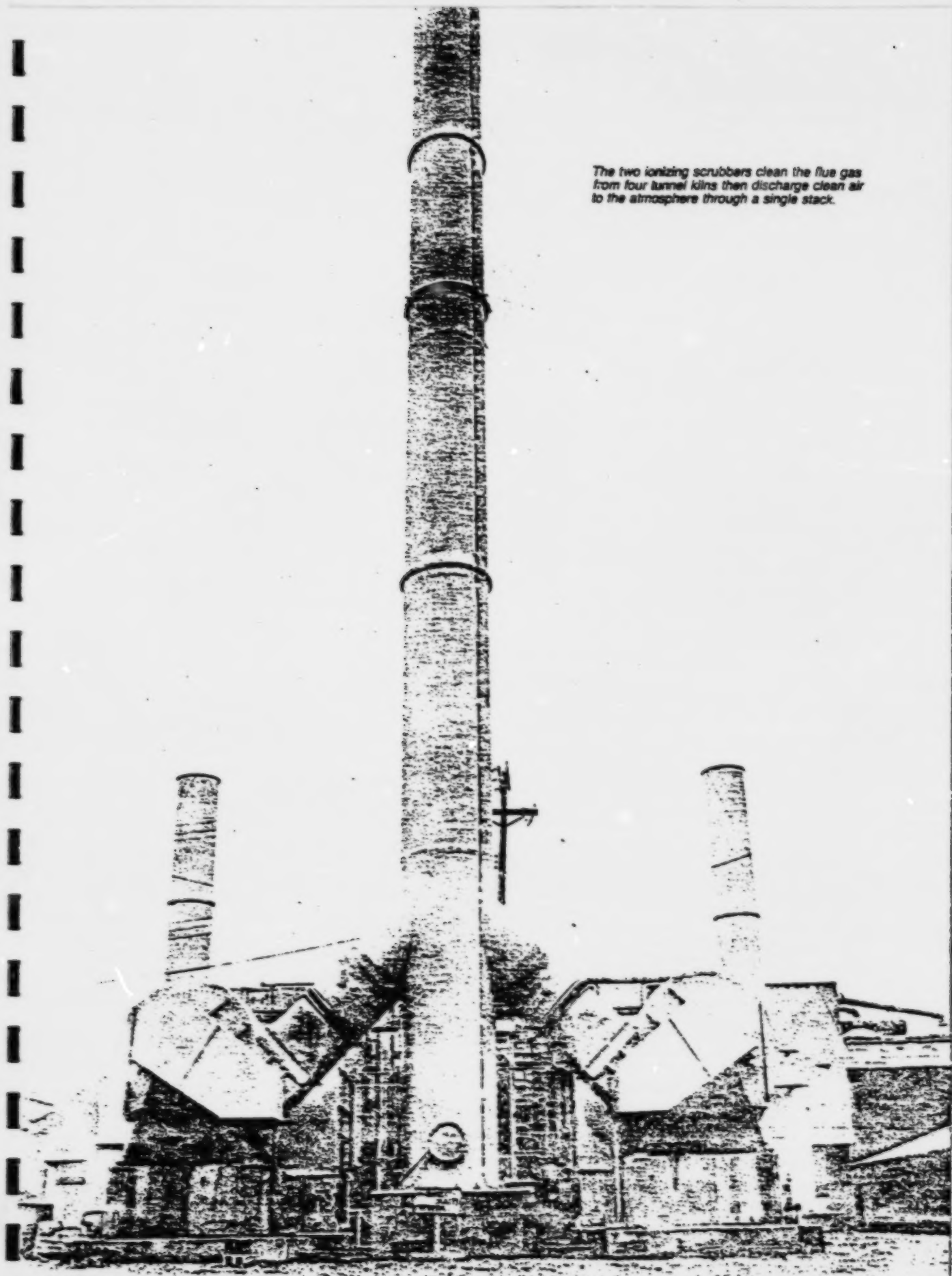


Giant flues bring tunnel kiln exhaust gases to both ionizing wet scrubbers.



Inside this high voltage ionizer, particles are given a charge.

The two ionizing scrubbers clean the flue gas from four tunnel kilns then discharge clean air to the atmosphere through a single stack.



CE **GLOBE REFRACTORIES**
COMBUSTION ENGINEERING, INC.



POURING PIT REFRACTORIES

More than 65,000,000 bloating type ladle brick annually in addition to a full line of refractory sleeves, nozzles and nozzle block—high alumina as well as clay. Here, at C-E Globe Refractories, is capacity unmatched by any other producer—and a constantly maintained inventory which assures fastest delivery, even 24-hour service when required.

Globe Refractories, Inc., a subsidiary of Combustion Engineering, Inc., and the world's largest manufacturer of pottery fire refractories is an integrated modern facility. It is a company which has automated and revolutionized the making of ladle brick, sleeves and nozzles while assuring the customer product of the best quality and performance.

Automated production is an almost uninterrupted sequence from forming to palletization of finished products. Every day's uninterrupted operations including raw materials sizing, storing, feeding, blending, brick forming, setting, drying and firing are pre-programmed to fulfill the most demanding delivery schedules and to maintain inventories precisely matched to forecast.

Picture the industry's largest tunnel kiln (65' x 16')—two ton brick fields, four the automated stackers for placing brick on kiln cars and automated dry pressing of thousands of sleeves in an automated sequence. Nozzles are automatically shaped to minimize laminations, then formed and mechanically carved to produce standard

Consider the sophisticated quality control which monitors every operation assuring reliable consistency in R.C.F.'s and other physical and chemical properties. Think of the experienced knowledgeable engineering staff which designs zoned ladle linings for individual customers based upon careful evaluation of wear patterns in order to achieve maximum service life and lowest possible refractory cost per ton of steel produced.

This is C-E Globe Refractories—over 100 years of organization wholly dedicated through service, products and technology to serving the steel industry.

FIRST IN HIGH ALUMINA BLOATING TYPE LADLE BRICK

C-E Globe Refractories was the first to serve the steel industry with bloating type 70% and 50% alumina ladle brick of consistent quality and properties. These products combine the refractoriness and erosion resistance of high alumina with the unique lining tightness afforded by bloating action. In today's fast cycling operations (e.g. continuous casting), these ladle brick mean a decided increase in the number of heats per lining, fewer re-lines, fewer delays, lower refractory costs.

FIRST IN AUTOMATED BRICKLAYING

In still another way, C-E Globe Refractories successfully attacked ladle availability and labor cost problems existing in short cycle pouring pit operations. Their new, different approach is their exclusive patented Globe Automated Bricklayer, or "GAB." This unique machine was engineered and designed by C-E Globe Refractories and is manufactured by the company for sale to the steel industry.

With the GAB, one or two men can line the working sidewall of a ladle at the rate of 1800 brick per hour. The unit consists of coordinated brick delivery and brick positioning systems for laying up semi-universal lining while automatically applying a uniform layer of mortar between each brick to assure tight joints.

C-E GLOBE REFRACTORIES PRODUCTS

GLOBE LADLE BRICK (Bloating Type)

C-E Globe Refractories' brick are dry pressed from clays outstanding for their bloating characteristics as well as consistent refractory properties. These brick form extremely tight, high strength linings which withstand the severe erosion and thermal spall conditions prevailing in short cycle operations and thereby furnish maximum heats at lowest refractory cost. They also assure high dimensional consistency for convenience in bricklaying. Available in 70%, 50% and 40% alumina and in fireclay grades and in all standard sizes and shapes, as well as special shapes, semi-universal series shapes and starter brick series.

GLOBE NOZZLES

Under pressure of the stopper rod head, a Globe nozzle makes an excellent positive seal and is

TECHNICAL DATA

Chemical and Physical Properties	Globe Ladle Brick Dry Press—Bloating Type			
	Clay	Alumina		
		40%	50%	70%
Chemical Analysis (%)				
Al ₂ O ₃ , Alumina	26.07	41.31	51.49	68.89
SiO ₂ , Silica	67.21	51.49	41.31	24.59
Fe ₂ O ₃ , Ferric Oxide	1.98	2.32	2.32	3.23
TiO ₂ , Titania	1.31	2.11	2.31	1.84
CaO Calcium Oxide	.18	.24	.24	.14
MgO Magnesium Oxide	.41	.36	.36	.23
Alkalies	2.69	2.20	1.70	.80
Bulk Density (lbs. per cu. ft.)	142	152	155	165
(oz. per cu. in.)	1.313	1.410	1.434	1.535
(gms. per cc.)	2.27	2.44	2.48	2.65
Apparent Porosity (%)	12-14	16-17	14-16	20-22
Modulus of Rupture (psi)	1730	1874	1800	1400
PCE	20-23	31-32	32-34	36+
Linear Reheat Expansion				
2350° F.	10-16	12.2	10.0	2.0
2460° F.	—	—	—	—
2910° F.	—	—	—	12.0

[illegible]

STANDARD SHAPES AND DIMENSIONS

GLOBE DRY PRESS LADLE BRICK

2 1/2" STANDARD SHAPES

Series	Shape	DIMENSIONS (In Inches)		
		Length	Width	Thickness
2 1/2"	Straight	8 3/4	4 1/4	2 1/4
	Split (1 1/4")	8 3/4	4 1/4 & 6	1 1/4
	Split (2")	8 3/4	4 1/4 & 6	2
	Soap	8 3/4	2 1/4	2 1/4
	Bevel No. 1	8 3/4	(4 1/4 - 4)	2 1/4
	Bevel No. 2	8 3/4	(4 1/4 - 3 1/4)	2 1/4
	Arch No. 1	8 3/4	4 1/4	(2 1/4 - 2 1/4)
	Arch No. 2	8 3/4	4 1/4	(2 1/4 - 1 1/4)
	Arch No. 3	8 3/4	4 1/4	(2 1/4 - 1 1/4)
	Wedge No. 1	8 3/4	4 1/4	(2 1/4 - 1 1/4)
	Key No. 1	8 3/4	(4 - 2 1/4)	2 1/4
	Key No. 1	8 3/4	(4 - 3 1/4)	2

3" STANDARD SHAPES

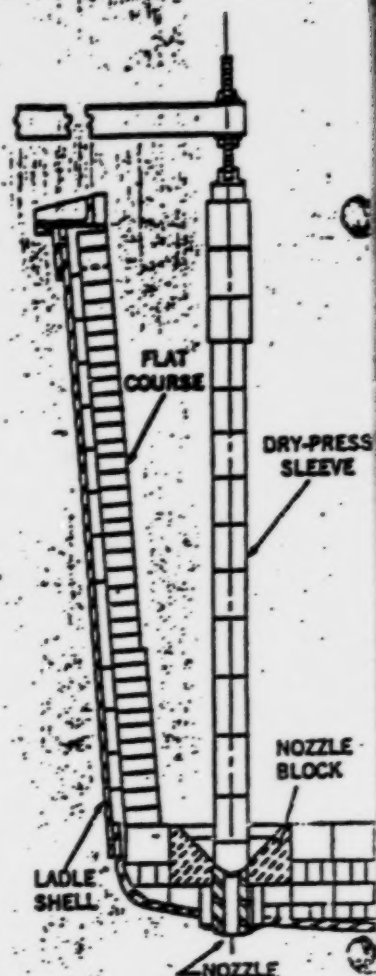
3"	Straight	8 3/4	4, 5, 6, 7, 9 & 10	3
	Bevel	8 3/4	(4 1/4 - 4)	3
	Arch No. 1	8 3/4	4	(3 - 2 1/4)
	Arch No. 1	8 3/4	5, 6 & 7	(3 - 2 1/4)
	Arch No. 2	8 3/4	5, 6 & 7	(3 - 2)
	Wedge No. 1	8 3/4	4	(3 - 2 1/4)
	Wedge No. 1	8 3/4	5, 6 & 7	(3 - 2 1/4)
	Key No. 1	8 3/4	(4 - 3)	3

3" SEMI-UNIVERSAL SHAPES

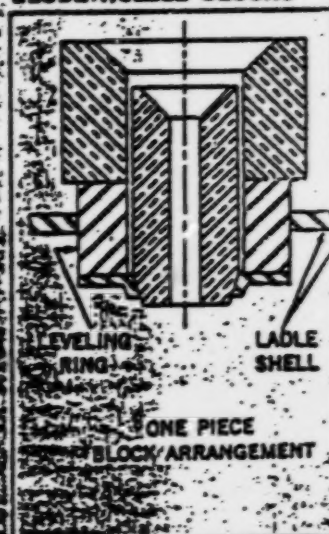
3"	Semi-Univ. 30, 45, 60	8 3/4	2, 4, 5, 6, 7, 8 & 9	3
	Half	4 1/4	4, 5, 6, 7 & 9	3
	Skew	8 3/4	9	3
	R-Skew	8 3/4	9	3
	9 Pe. Starters	8 3/4	5, 6, 7 & 9	3
	18 Pe. Starters	8 3/4	5, 7 & 9	3
	Univ. Straights	8 3/4	5, 7 & 9	3
	Skew	8 3/4	5, 7	3

4" STANDARD SHAPE

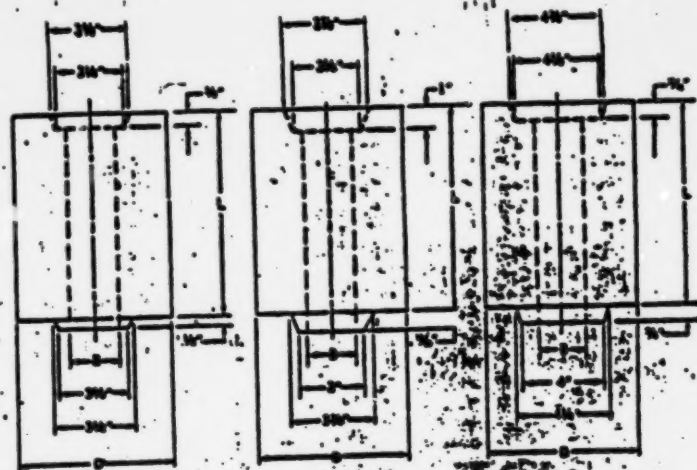
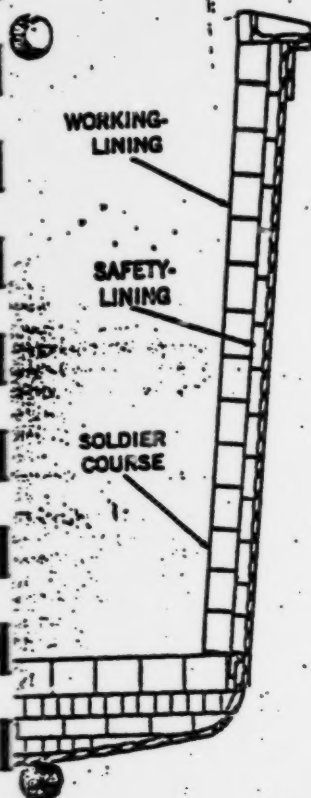
4"	Straights	8 3/4	5 & 6 1/2	4
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GLOBE NOZZLE BLOCKS



GLOBE STANDARD SLEEVES



JOINT NO. 1

JOINT NO. 2

JOINT NO. 3

B (Bore) — 2", 2½", 2¾", 3"

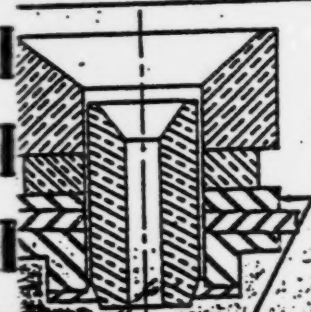
D (Diameter) — 6", 6½", 7", 8", 9"

L (Length) — 3" to 18"

GLOBE SLEEVE DIMENSIONS STANDARD SHAPES

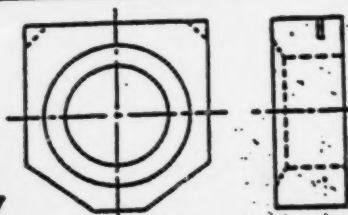
(Special sleeves can be furnished to customer specifications)

GLOBE NOZZLES



LEVELING RING

TWO PIECE BLOCK ARRANGEMENT



BLOCK WITH CUT CORNERS

Block are available in regular clay, 50% Al₂O₃ and 70% Al₂O₃ grades and are usually made to customer specifications in either one-piece or two-piece arrangements (see illustrations for comparison). Block design, composition and arrangement are determined by ladle capacity and design and technical data pertinent to the application.

STRAIGHT BOWL



BULLET-NOSE SNOUT

CONVEX BOWL



OFFSET SNOUT

The bullet-nose snout nozzle, which fits most currently used nozzle plates, is available in Globe standard dimensions as follows:

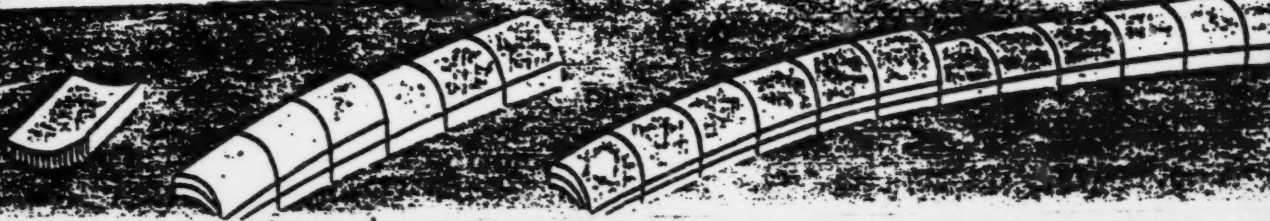
Diameter — 6", 6½", 6¾", 7", 7½", 8", 9", 10"

Lengths Up to 18"

Bore — 1½" to 5"

Since bore requirements change from time to time according to the grade and type of steel being poured, these standard dimensions permit interchangeability of lengths and bores, and quick availability of required nozzles from stock.

Offset snout nozzles and, where desired, convex bowl nozzles are manufactured to customer specifications.





POURING PIT REFRACTORIES

Outstanding service... from the world's largest source of pouring pit refractories

With an annual capacity of 90,000,000 ladle brick, stopper rod sleeves, nozzles and nozzle block—alumina as well as clay, C-E Globe Refractories is the world's largest source of highest quality pouring pit refractories. This unmatched capacity assures a vast, constantly maintained inventory to meet the most demanding shipping schedules, including 24-hour service.

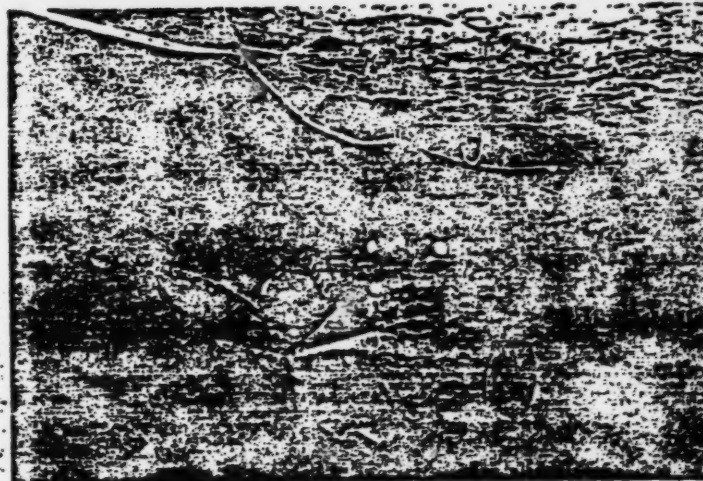
The huge, integrated, modern C-E Globe Refractories manufacturing and mining facility is located at Newell, West Virginia, on the Ohio River, within convenient reach, by rail, truck and barge, of all major steel producing areas. Here, the company has automated and revolutionized the making of pouring pit refractories, assuring customers products of highest quality and in adequate quantities at all times.

Picture the industry's two largest tunnel kilns, each 632 feet (more than two football fields) long, the bank of automated stackers for placing brick on kiln cars, the automatic dry pressing of thousands of sleeves and nozzles. Dry pressing instead of extruding combined with efficient tunnel kiln firing means burning times of a few days *vs.* a few weeks, helps maximize production and permits greater dimensional and quality control. An environmentally concerned company, C-E Globe Refractories is in full compliance with federal and state air and water pollution control regulations.

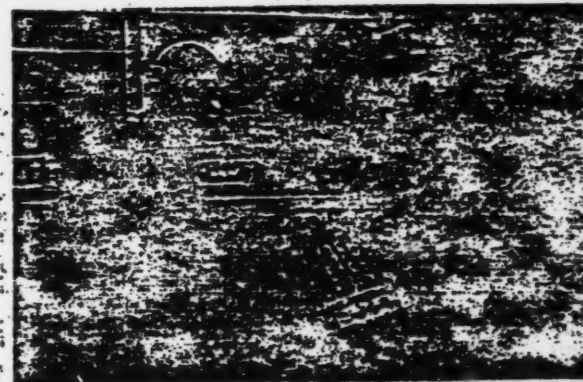
An uninterrupted, automated sequence, from dry pressing through transporting, firing and cooling



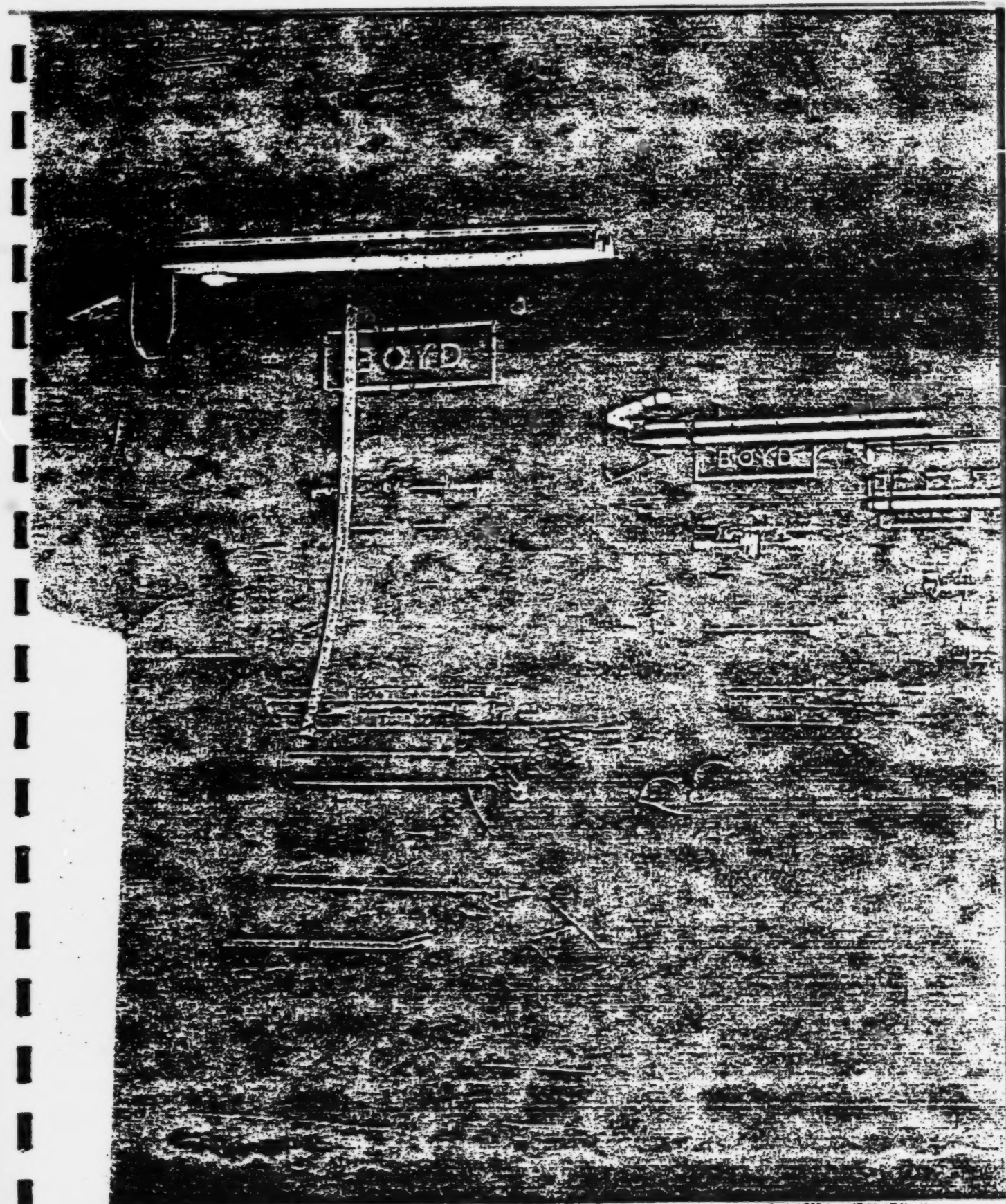
24-hour service, 7 days a week



On-site raw materials



Centrally controlled, computerized manufacturing operations



matic dry pressing of ladle brick.

Computerized production... continuous quality control

Production at C-E Globe Refractories is an uninterrupted sequence from on-site raw materials mining to palletization of finished products.

Computerized, interlocked operations, including raw materials sizing, storing, feeding and blending, product forming, setting, drying and firing, are programmed to meet delivery schedules and to maintain inventories matched to forecast. Blending, moisture content, grain sizing and firing temperatures are continuously centrally monitored to assure consistency of PCE's and other physical and chemical properties. Finished products are critically tested at frequent regular intervals.

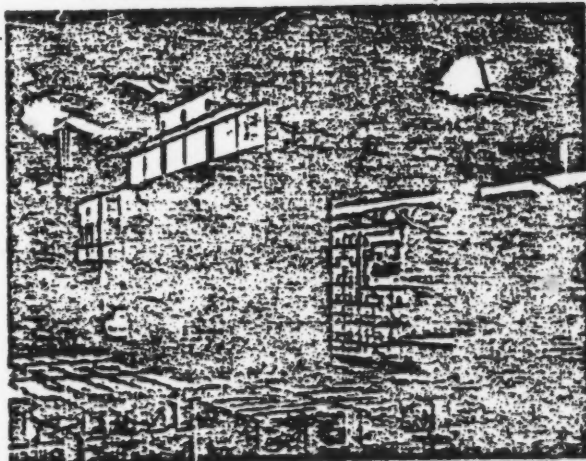
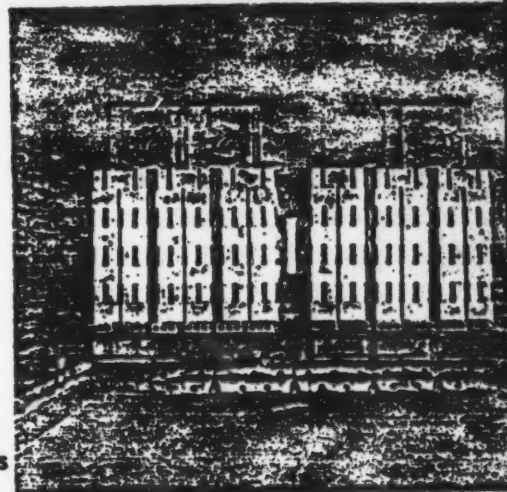
First in alumina bloating type ladle brick

C-E Globe Refractories was the first to serve the steel industry with bloating type alumina brick of consistent properties and quality. These brick combine the refractoriness and erosion resistance of alumina with the unique lining tightness afforded by bloating action. In today's fast cycling operations, these brick mean a decided increase in heats per lining, fewer relines, fewer delays and lower refractory cost.

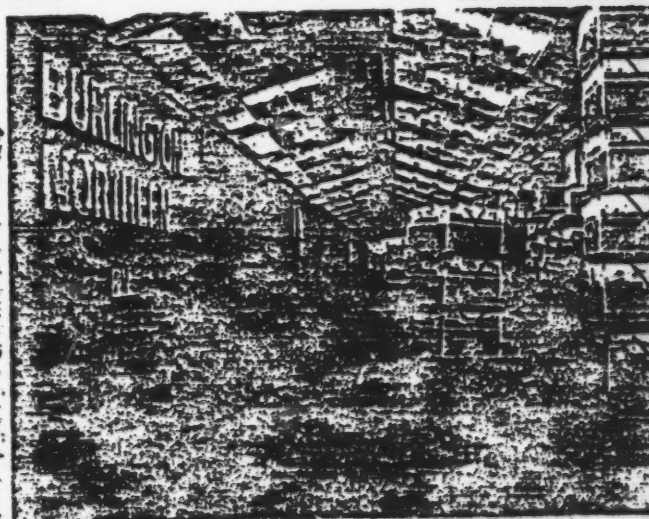
Cost reduction through engineered linings

The experienced, knowledgeable C-E Globe Refractories engineering staff can help individual customers by designing zoned linings, based on careful evaluation of wear patterns, to achieve maximum service life and lowest refractory cost per ton of steel.

More than
75,000,000 Globe
bloating type ladle
brick a year move
through these 632-
foot long continuous
tunnel kilns.

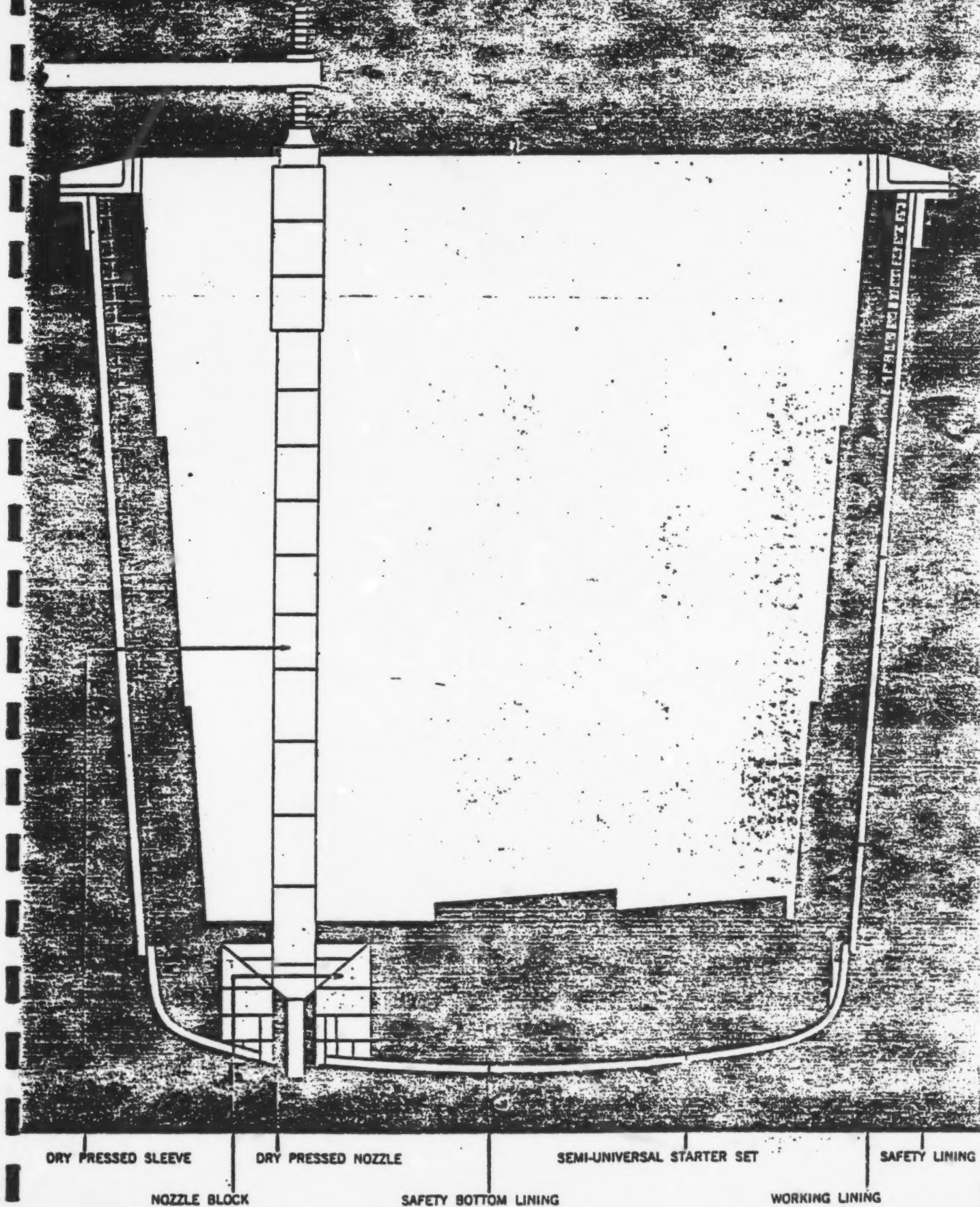


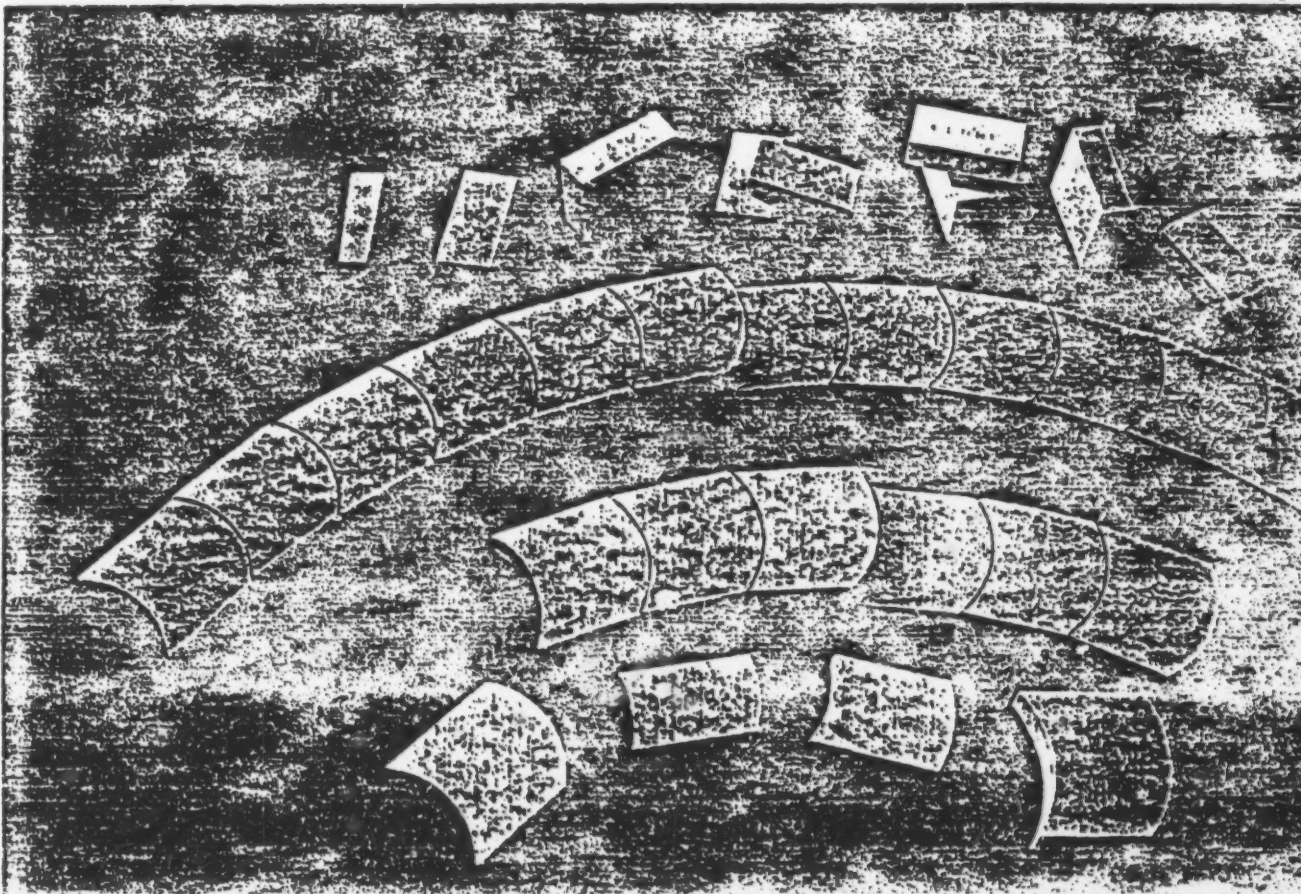
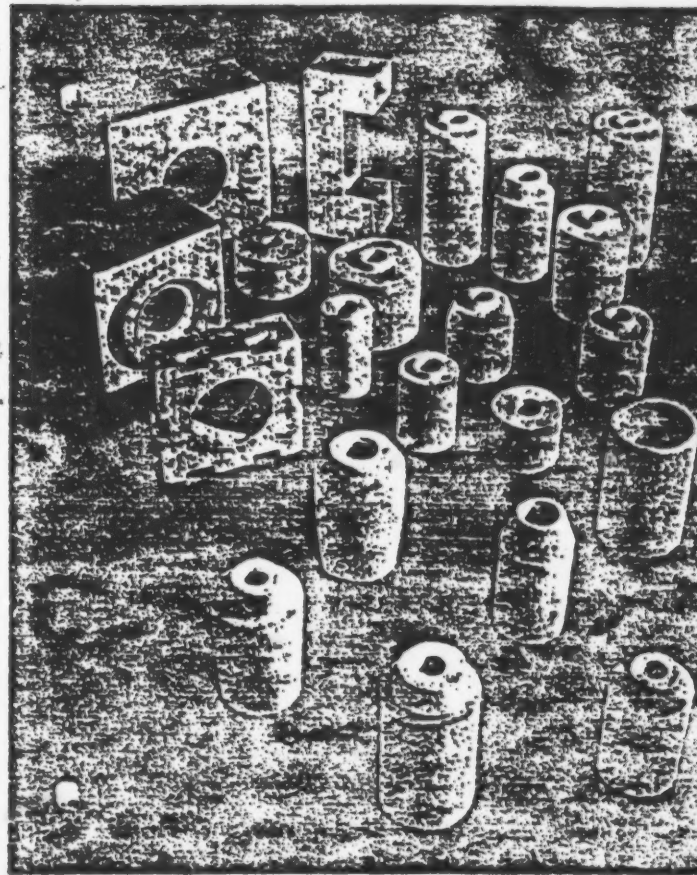
Immediately following the dry pressing operation, brick are automatically set on kiln cars for transport to the tunnel kilns.



Rapid access to all major steel-producing areas — by rail, by truck and by barge — assures the highest level of service to C-E Globe Refractories customers.

EGLOBE REFRACTORIES PRODUCTS





C-E GLOBE REFRACTORIES PRODUCT DATA

STANDARD SHAPES AND DIMENSIONS

STANDARD SHAPES

SHAPE DIMENSIONS (in inches)
Length Width Thickness

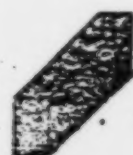
STRAIGHT	12 1/2	4 1/2	2 1/2
SPLIT	12 1/2	4 1/2	2 1/2
SOAP	12 1/2	4 1/2	2 1/2
BEVEL	12 1/2	4 1/2	2 1/2
ARCH	12 1/2	4 1/2	2 1/2
WEDGE	12 1/2	4 1/2	2 1/2
KEY	12 1/2	4 1/2	2 1/2
SEMI-UNIVERSAL	12 1/2	4 1/2	2 1/2
UNIVERSAL STRAIGHT	12 1/2	4 1/2	2 1/2
UNIVERSAL SKEW	12 1/2	4 1/2	2 1/2

STRAIGHT	12 1/2	4 1/2	2 1/2
SPLIT	12 1/2	4 1/2	2 1/2
SOAP	12 1/2	4 1/2	2 1/2
BEVEL	12 1/2	4 1/2	2 1/2
ARCH	12 1/2	4 1/2	2 1/2
WEDGE	12 1/2	4 1/2	2 1/2
KEY	12 1/2	4 1/2	2 1/2
SEMI-UNIVERSAL	12 1/2	4 1/2	2 1/2
UNIVERSAL STRAIGHT	12 1/2	4 1/2	2 1/2
UNIVERSAL SKEW	12 1/2	4 1/2	2 1/2

STRAIGHT	12 1/2	4 1/2	2 1/2
SPLIT	12 1/2	4 1/2	2 1/2
SOAP	12 1/2	4 1/2	2 1/2
BEVEL	12 1/2	4 1/2	2 1/2
ARCH	12 1/2	4 1/2	2 1/2
WEDGE	12 1/2	4 1/2	2 1/2
KEY	12 1/2	4 1/2	2 1/2
SEMI-UNIVERSAL	12 1/2	4 1/2	2 1/2
UNIVERSAL STRAIGHT	12 1/2	4 1/2	2 1/2
UNIVERSAL SKEW	12 1/2	4 1/2	2 1/2

GLÖBE LADLE BRICK (Bloating Type)

These bricks are dry pressed from clays outstanding for their bloating characteristics as well as for consistent refractory properties. They form extremely tight, high strength linings which withstand the severe erosion and thermal spall conditions prevailing in fast cycling operations and thereby assure maximum heats and lowest refractory cost. Available in 70%, 50% and 40% alumina and in fireclay grades in semi-universal series shapes and starter sets, and in standard sizes and shapes and special shapes. See information at left.



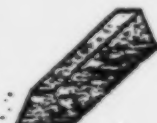
STRAIGHT



SPLIT



SOAP



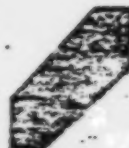
BEVEL



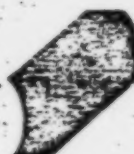
ARCH



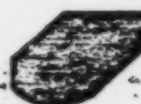
WEDGE



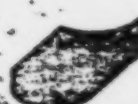
KEY



SEMI-UNIVERSAL



UNIVERSAL STRAIGHT



UNIVERSAL SKEW



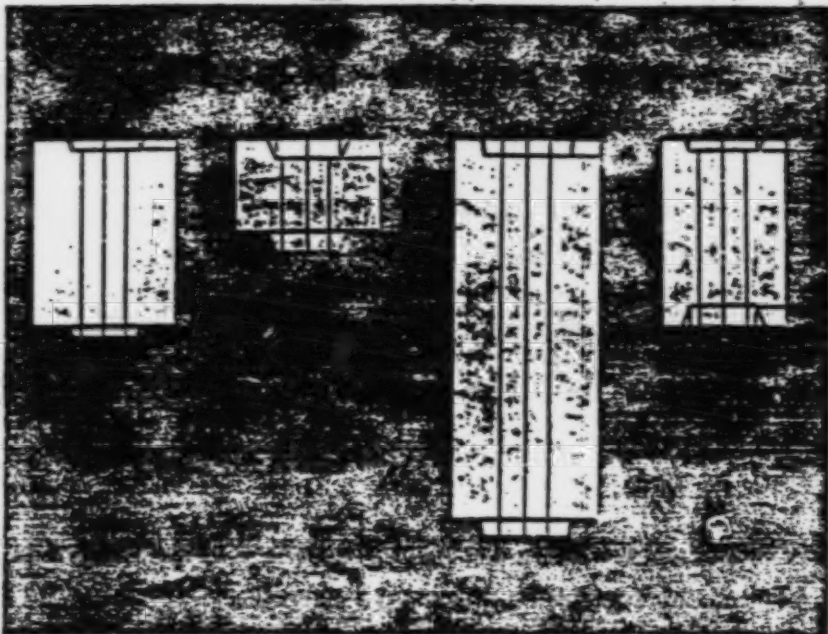
SEMI-UNIVERSAL 9-PC. STARTER SET



SEMI-UNIVERSAL 18-PC. STARTER SET



SEMI-UNIVERSAL 24-PC. STARTER SET



GLOBE STOPPER ROD SLEEVES

Globe Sleeves are dry pressed for superior resistance to spalling and erosion and for dimensional uniformity. Used with a high quality mortar, such as C-E Refractories Super #3000, they produce one of the most successful stopper rod covers. Available in 70% and 50% alumina grades, as well as clay, in choice of several standard diameters and joint designs. See sketches at right. Special sleeves can be produced to customer specifications.

GLOBE NOZZLES

Dry pressed for dimensional consistency. Under the pressure of the stopper rod head, a Globe Nozzle makes an excellent positive seal and is outstanding for controlled erosion during pouring. Available in bloating and non-bloating fireclay grades PCE 23-26 and PCE 29, and in several designs represented by the sketches. Nozzles are designed and manufactured to customer specifications and are then available from stock.

Nozzles are manufactured in the following sizes:
Diameters: 6", 6¼", 6½", 6¾", 7", 7¼", 7½", 8", 9", 10"

Lengths: Up to 18"
Bores: 1", 5"

GLOBE NOZZLE BLOCK

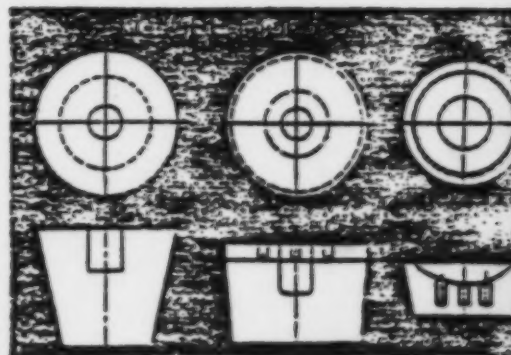
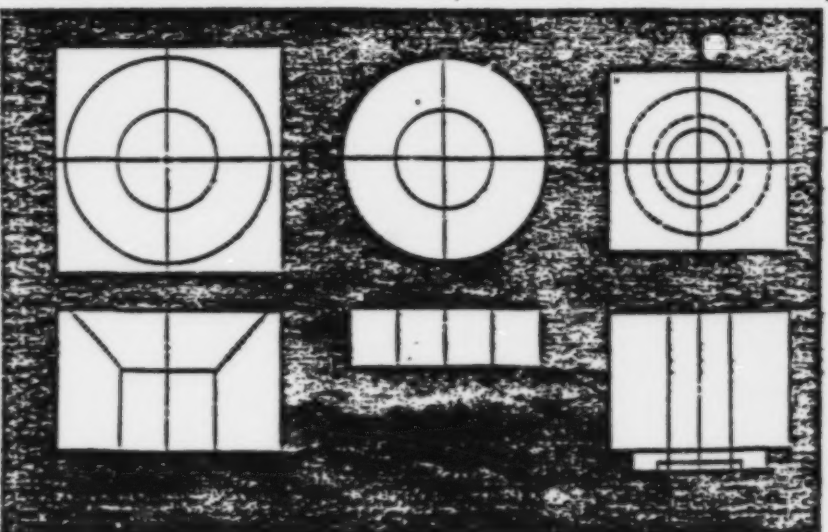
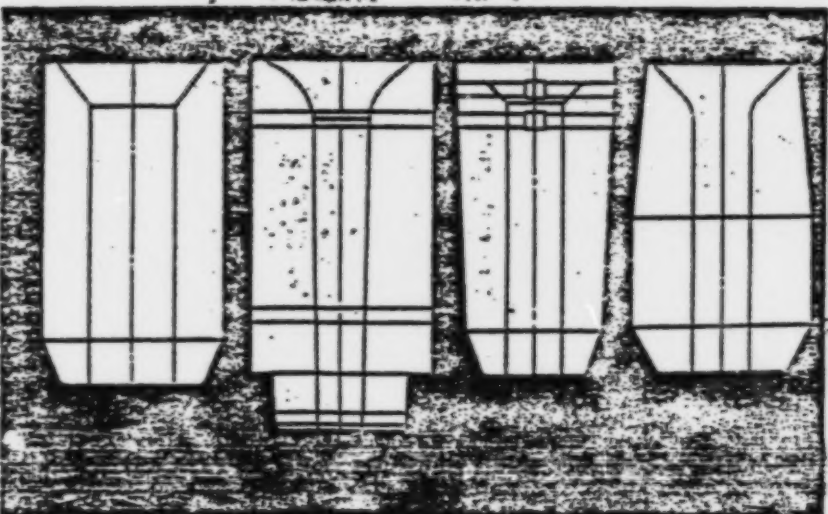
Globe Nozzle Block are fired, ready-to-use refractory shapes. They are noted for unusually high strength and impact resistance as well as resistance to metal and slag erosion. Globe Nozzle Blocks are available in 50% alumina and fireclay grades and are designed to the customer's specifications in either one- or two-piece arrangements. Block design, composition and arrangement are determined by ladle size and design and other technical data pertinent to the application. Some typical configurations are shown at the left.

GLOBE LADLE SPRAY

A high quality fireclay mix for hot gun veneer on ladle lining surfaces. Used in a C-E G Refractories engineered gunning program increases lining life and reduces refractory cost per ton of steel.

GLOBE MOLD PLUGS

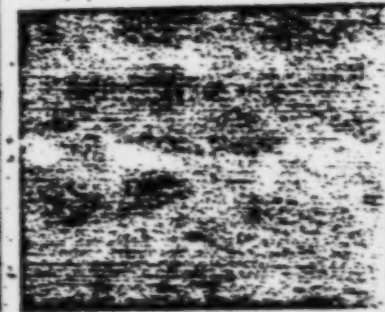
For big-end-up, plug bottom ingot molds. Designed and manufactured to customer specifications. Typical configurations are shown below.



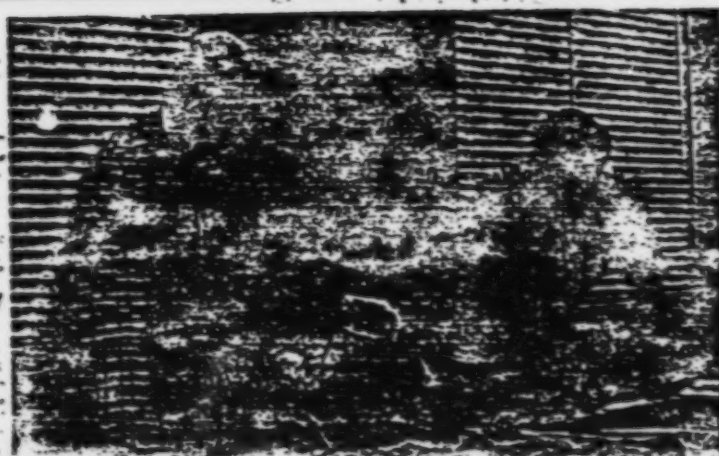
Programmed quality control means product uniformity, shipment after shipment, year in and year out. Here, a C-E Refractories technician confirms established PCE's (pyrometric cone equivalents)



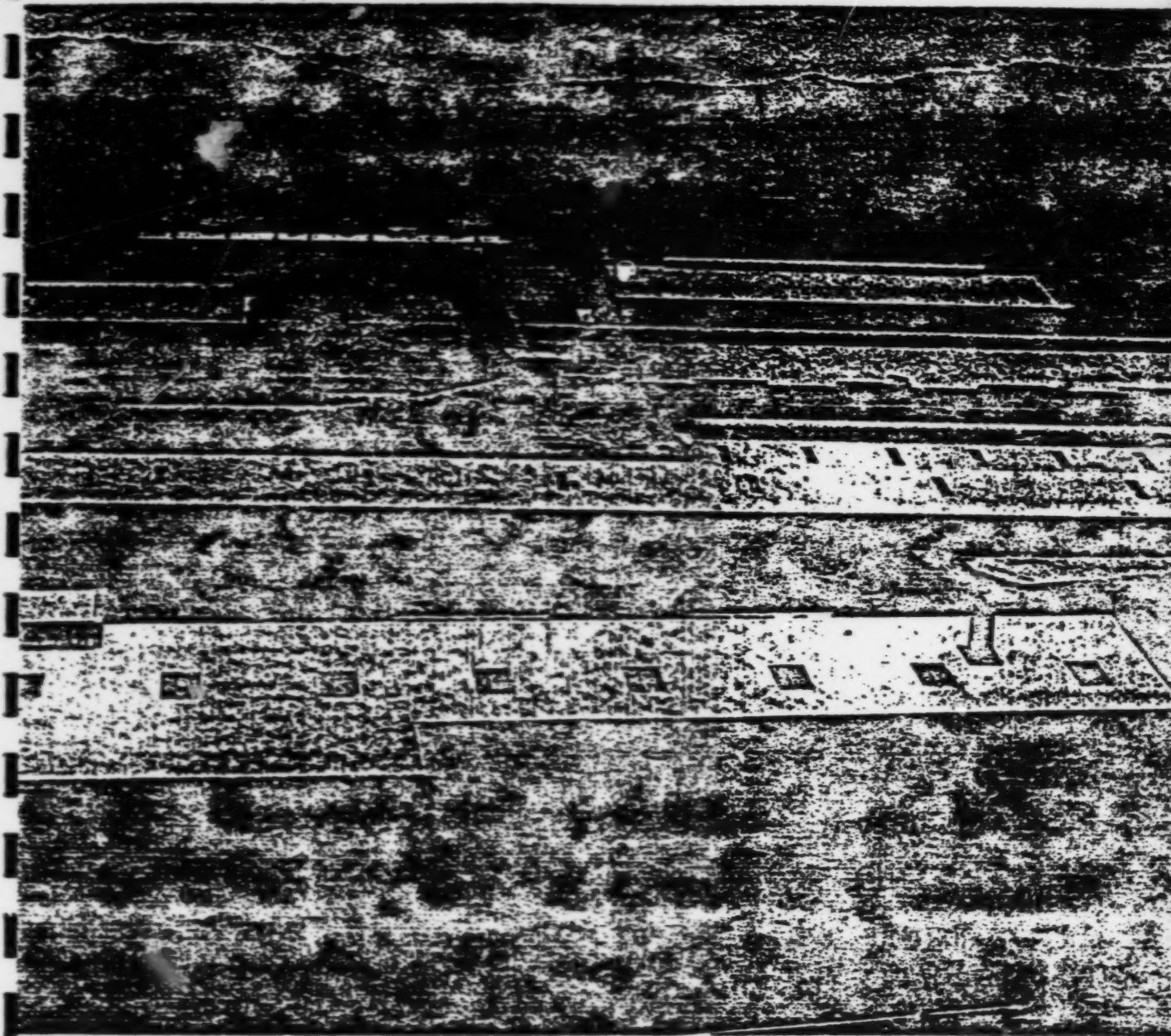
Globe semi-universal ladle brick and nozzles ready for final inspection, packaging and shipment



To help reduce refractory costs, C-E Globe Refractories engineers can design linings based on individual wear patterns and pouring practice



Part of the half-mile long, integrated C-E Globe Refractories facility at Newell, West Virginia, incorporating the first and largest automated plant for producing pouring pit refractories



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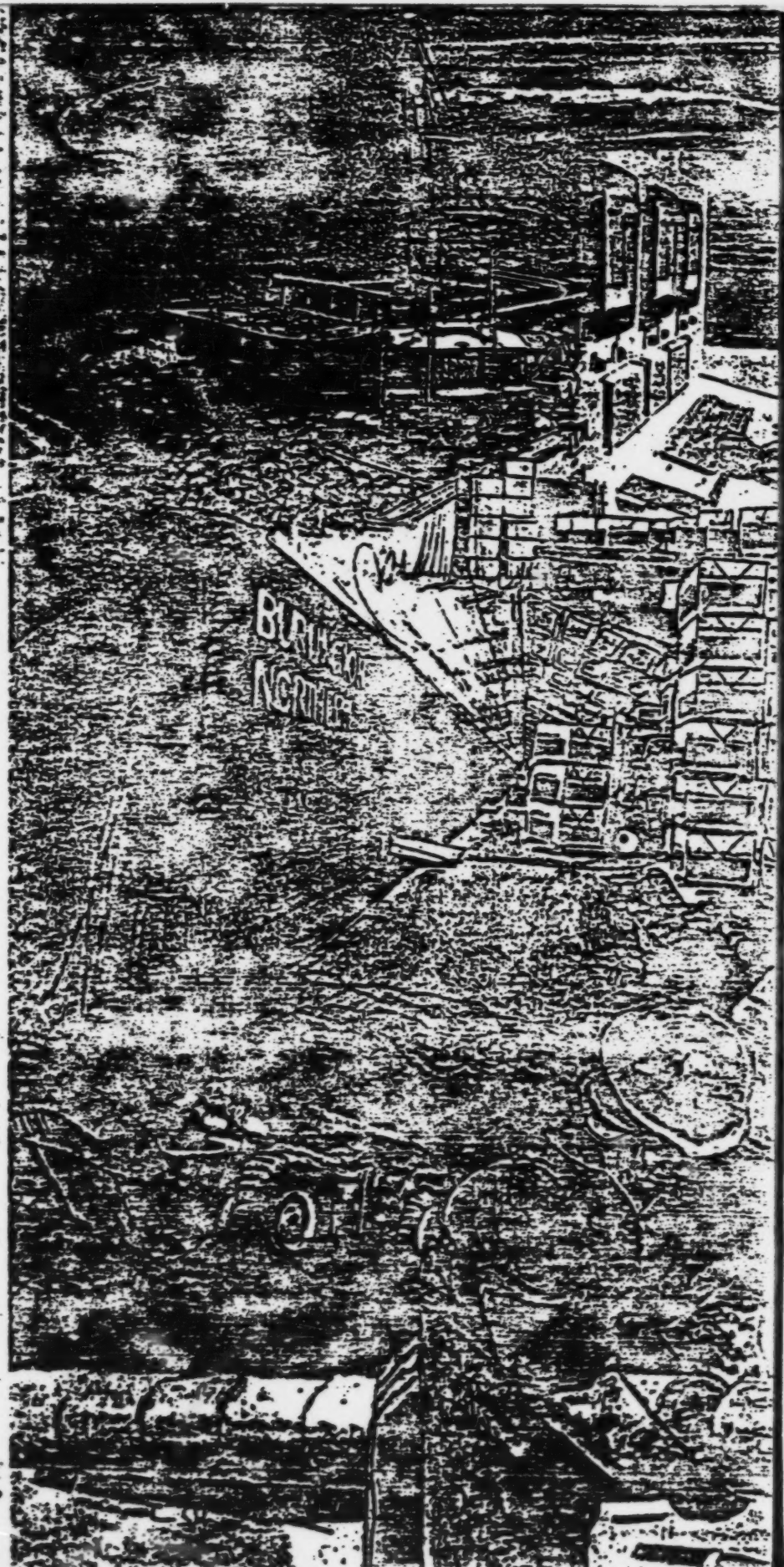
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3

CONTRACT REPORT NO. OSQ82-00090

A REVIEW OF THE INFLUENCE OF FLUORIDE-EMISSION CONTROL
SYSTEMS ON THE ENERGY EFFICIENCY OF TUNNEL KILNS
MANUFACTURING STRUCTURAL CLAY PRODUCTS

Milestone Report

prepared by

E.E. Berry
(Project Manager)

21 AP

November 26th, 1982

DSS Contract: OSQ82-00090
DSS File No. 26SQ.23440-2-9056

OCT 26 1984
MICROMEDIA

Introduction

The objective of this project is to address two aspects of the preliminary work required for the design of a co-ordinated industry wide research effort on the subject of the relationships between fluoride emission control and the energy efficiency of brick tunnel kilns, namely:

- To prepare complete critical review and updated literature survey of the current state-of-the-art with respect to the following items:
 - (a) brick kiln energy efficiency;
 - (b) fluoride emission control technology;
 - (c) basic research on the thermochemistry of fluoride evolution from typical raw materials.
- Based upon the above review, to prepare a detailed research program in the form of work statements and cost estimates.

This report addresses the first project milestone: the completion of the accumulation of a literature and industry data base.

Project Status

The preparation of the literature data base has been completed under the direction of Dr. I. H. Joyce at the Ontario Research Foundation. Dr. Joyce prepared a review of fluoride emissions in the brick industry and the potential for their control for CBAC in December 1979, and an up-date of this document has been the major portion of the effort dedicated to the preparation of the data base. Information compiled by individual brick companies was also searched for inclusion in the data base.

The technical and scientific literature on brick tunnel kiln efficiency, fluoride emission control technology and research on the thermochemistry of fluoride evolution was searched through the following computer sources:

- | | |
|----------------------------|---|
| - Chemical Abstracts | - 1967 to present |
| - Engineering Index | - 1972 to present (also known as Compendix) |
| - Energy Line | - 1971 to present |
| - Enviroline | - 1971 to present |
| - Environment Bibliography | - 1974 to present |
| - Pollution Abstracts | - 1970 to present |
| - NTIS | - 1964 to present |

The search profile used is given in Appendix 1.

As a result of these searches, 2527 initial citations were identified, these were progressively reviewed to compile a list of 93 relevant references, abstracts of which are given in Appendix 1.

Because much of the information relevant to the topic is not generally available through published literature, visits were made to research establishments, technical institutes and engineering companies in Europe and the U.S.A. known to be active in the field. These visits were made by an industry technical task force comprising of Mr. J. F. Nicks of Domtar Inc., Mr. J. P. Storer-Folt of Canada Brick Co. Ltd. and Mr. H. Penn of Brampton Brick Ltd.. This task force has reviewed the current developments in research and technology from an industry perspective. The findings of the task force were collected and will be incorporated into the critical review. The itinerary of task force visits is summarised in Appendix 2.

The following major points were noted by the industry task force:

(a) Emission Regulations

European countries are aware of the potential problem of fluoride emissions and the general regulatory approaches are similar in the following respects.

- Older plants are not forced to meet emission regulations except where substantial damage to foliage, animals, property or people occurs. Under these conditions changes to emission levels are enforced.
- The general cost/benefit aspects of enforcement are considered and Governments do not force unnecessary application of regulations where they exist.

(b) Energy Impacts of Emission Control

Emission controls need not always cause an energy penalty. The dry absorption system has been found practicable in Germany, French plants have used a wet system. A dry system for use in Canada would require modification to accommodate climatic conditions, these would result in an energy penalty.

The thermochemistry of fluoride emissions has been investigated but more R & D is needed.

Corrosion and operating problems were frequently reported by operators of gas scrubbing systems in Europe.

A preliminary review of the results from the literature search and the task force visits has confirmed that, whereas there is general awareness of the need to consider the possible impact of the control of fluorine (and other) gaseous emissions on kiln energy efficiency very little directly relevant work has been carried out. The most advanced work in this regard is to be found in reports from Germany.

Overall, it is considered that the following are the fluorine control methods showing the most promise of success with the least potential for negative impact on energy consumption:

- Control of raw materials
- The use of additives
- Modifications to kiln firing profiles.

These approaches, singly or in combination will be considered further as the development of work statements continues.

Preliminary research topics, to be discussed with the technical steering committee, have been generated on the basis of this evaluation of the state-of-the-art these are listed below.

1. Examination of fluorine evolution profiles for currently employed and major potential sources of Canadian brick-making materials.
2. Preliminary screening of potential fluorine control additives and fluxes, followed by examination of selected materials in the laboratory to establish their effects on fluorine evolution characteristics.
3. Base-line data collection on energy and emissions characteristics of selected Canadian brick kilns.
4. Design and implementation of laboratory experiments to evaluate the effects of thermal profile modifications on F⁻ evolution.
5. Plant evaluation of modifications to the thermal profiles of selected kilns.

APPENDIX 1

Key words used in the literature search:

Clay
Ceram.
Brick
Kiln
Fluoride
Fluorine
Evolution
Emission
Pollut.
Control
Energy
Efficiency
Conservation
Optimiz.
Chemi.
Reaction

48/3/1

G7841D3 N82-27515/7 NTIS Prices: PC A04/MF A01

Fluorine Emission During Ceramic Firing; Final Report.

Tuenker, G.; Schmidt, H.; Scholze, H.

Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung e.V.,
Wuerzburg (Germany, F.R.). Inst. fuer Silicatforschung.*National
Aeronautics and Space Administration, Washington, DC.

Dec 81 70p

Rept No: BMFT-FB-T-81-231; ISSN-0340-7608

-In German; English Summary.- Sponsored by Bundesministerium fuer
Forschung und Technologie.

16/3/1

97114148 CA: 97(14)114148n TECHNICAL REPORT

Fluorine emission during the ceramic firing process

AUTHOR: Tuenker, Gerhard; Schmidt, Helmut; Scholze, Horst

LOCATION: Fraunhofer-Inst. Silicatforsch., 8700, Wuerzburg, Fed. Rep

Ger.

JOURNAL: Forschungsber. - Bundesminist. Forsch. Technol., Technol. Forsch
Entwickl. DATE: 1981 NUMBER: BMFT-FB-T 81-231 PAGES: 70 pp

CODEN: BFTEAU ISSN: 0340-7608 LANGUAGE: German

9/5/5

724932 ID NO.- EI770424932

IMMISSIONSPROBLEME IN DER ZIEGELINDUSTRIE. \$left bracket\$ Immission
Problems in the Brick Industry \$right bracket\$.

Berge, Helmut

Vegetationsversuchsanst. Heiligenhaus, Ger

Staub Reinhalt Luft v 36 n 12 Dec 1976 p 460-465 CODEN: STRHAV

The problem discussed in the paper is the attitude towards the standard
value for immission of hydrogen fluoride. The difficulty in maintaining
the limiting value for hydrogen fluoride by means of the lime injection
method, which appears to be more economic than the wet method, is to be
considered as the most vital problem of the brick industry, because of new
immissions (dust). Different proposals as to the investigations in the
case of damage due to immissions are described. 15 refs. In German with
English abstract.

DESCRIPTORS: (*INDUSTRIAL PLANTS, *Fume Control), (BRICKMAKING, Fly Ash),
HYDROGEN, DUST ABATEMENT,

IDENTIFIERS: HYDROGEN FLUORIDE

CARD ALERT: 414, 451, 804, 812

9/5/2

958960 ID NO.- EI790858960

COMPOSIZIONE E COMPORTAMENTO DEI GAS ESAUSTI DI FORNO IN RELAZIONE ALLA
CORROSIONE NELL'INDUSTRIA DEI LATERIZI OLANDESE. \$left bracket\$ Corrosion
Effects and Composition of Exhaust Gases in Dutch Brick Factories \$right
bracket\$.

De Jonse, L. S.

Sticht Tech Cent voor de Grafkeram Ind, Arnhem, Olanda, Sued

Ceramurgia Tec Ceram v 9 n 1 Jan-Feb 1979 p 13-16 CODEN: CRGIAR

An investigation was made on the composition of flue gases from kilns in
brickmaking plants. The content of sulfur, fluorine, chlorine and nitric
oxides were monitored for three years. Because of the fact that
concentrations of these components were found in exhaust gases it is
assumed that rather rapid corrosion was due to these elements. In Italian
with English translation.

DESCRIPTORS: (*BRICKMAKING, *Kilns),

CARD ALERT: 414, 812

16/5/3

774334 ID NO.- EI771074334

FLUORID-EMISSIONEN AUS ANLAGEN ZUM BRENNEN KERAMISCHER ERZEUGNISSE. \$left bracket\$ Fluoride Emission from Plants Designed for Firing Ceramics \$right bracket\$.

Bernert, J.; Schubert, P.

Wasser Luft Betr v 21 n 3 Mar 1977 p 122-124 CODEN: WSLBAK

The contribution for preventing air pollution is presented in which particular attention has been devoted to the relationship between fluoride emission and furnace temperature. 9 refs. In German with English abstract.

DESCRIPTORS: (*INDUSTRIAL PLANTS, *Fume Control), (AIR POLLUTION, Control), (CERAMIC PLANTS, Kilns), FLUORINE COMPOUNDS.

CARD ALERT: 402, 451, 804, 812

16/5/4

740924 ID NO.- EI770640924

ERFAHRUNGEN MIT EMISSIONSMESSUNGEN IN DER KERAMISCHEN INDUSTRIE. \$left bracket\$ Emissions from Ceramic Kilns \$right bracket\$.

Jessen, Klaus; Schmidt, Ernst

Ziegelforsch, Essen, Ger

Ber Dtsch Keram Ges v 54 n 1 Jan 1977 p 5-7 CODEN: BDKGAY

Experimental results of measured data on emissions from ceramic kilns, using various fuels are plotted in different graphs. The effects of stack height on fluorine dispersion at the ground, at various distances from the source, are also investigated.

DESCRIPTORS: (*KILNS, *Environmental Impact), (CERAMIC PRODUCTS, Manufacture),

CARD ALERT: 842, 812

16/5/5

722565 ID NO.- EI770422565

ERGEBNISSE VON EMISSIONSMESSUNGEN AN ANLAGEN DER KERAMISCHEN INDUSTRIE VON VERGLEICHE MIT GENEHMIGUNGSBEDINGUNGEN. \$left bracket\$ Results of Emission Measurements at Ceramic Works and Comparisons with Consent Conditions \$right bracket\$.

Gilbert, Traugott

Rheinisch-Westfael Tech Ueberwachungsver, Essen, Ger

Ber Dtsch Keram Ges v 53 n 3 Mar 1976 p 90-93 CODEN: BDKGAY

The RW-TUV of Essen have in recent years carried out extensive emission measurements at ceramic works. In the vicinity of tunnel kilns, in dryers and preparation departments the imposed dust limits, viz., 50-680 mg dust per cubic meter of waste gas, can always be adhered to. There were difficulties with one rotary kiln and where a bloating process was conducted. In modern works the requirements of the TA Luft (1974) with respect to dust and silica emission could be fulfilled. But this cannot be said about the emission of F compounds: 70% of the works investigated could not fulfill the requirements. It was found that assuming the conditions in the rest of the industry are similar to those at the works investigated, the emission limit of 30 mg fluorine per cubic meter laid down by the TA Luft (1974) for modern works cannot be complied with without special emission-control measures in 56% of brick-and-tile works and 27% of other ceramic works. 5 refs.

DESCRIPTORS: (*CERAMIC PLANTS, *Kilns), (KILNS, Measurements),

CARD ALERT: 642, 812

16/5/6

607866 ID NO.- EI760207866

CHARACTERIZATION OF AIR POLLUTANTS EMITTED FROM BRICK PLANT KILNS.

Wilson, Hugh H.; Johnson, Larry D.

Environ Prot Agency, Research Triangle Park, NC

Am Ceram Soc Bull v 54 n 11 Nov 1975 p 990-991, 944 CODEN: ACSBA7

Because of the lack of published effluent gas composition data from brick production in the United States, the EPA undertook a preliminary study of selected plants to gather data to be used as a guide for further work. Chemical and mineral analyses of the unfired and fired products, concentrations of pollutants in the stack gases and calculated emission factors are given. The major pollutants found were SO₂, SO₃ and fluorine. 10 refs.

DESCRIPTORS: (*BRICKMAKING, *Kilns), (KILNS, Smoke Abatement),

CARD ALERT: 414, 642, 812

16/5/7

230347 ID NO.- EI72X030347

Fluorine contents of air plants in the surroundings of a brick kiln. (Fluorgehalte von Luft und Pflanzen in der Umgebung einer Ziegelei)

QUELLMALZ E; OELSCHLAEGER W

Staub - Reinhaltung Luft v 31 n 5 May 1971 p 206-8 CODEN: STABA

Fluorine immission measurements in the surroundings of a brick kiln showed a considerable increase in fluorine absorption during the vegetation period. It was found that in the case of an unfavorable position of the emission source even a relatively high chimney does not reduce the damage to plants. 11 refs. In German.

DESCRIPTORS: *AIR POLLUTION, FLUORINE, (BRICKMAKING, Fly Ash),

CARD ALERT: 414, 451, 803, 812

16/5/8

142590 ID NO.- EI71X042590

Fluorine content of refractory clays and fluorine emission during firing of fire- clay products. (Der Gehalt an Fluor in feuerfesten Tonen und Schamotte und die Beeinflussung der Fluorabgabe beim Brand der Schamotteeerzeugnisse)

ROUTSCHKA G; BUTTGEREIT CH; BERGER U

Sprechsal Keram, Glas, Email, Silikate v 103 n 20 Oct 2 1970 p 901-6

Fluorine content of refractory clays is in the range between 0.03 and 0.06%. During the firing process about 40% of original F content is emitted. Rate of emission is affected by the composition of firing atmosphere compared against air: both SO₂ and steam, particularly the latter, increase rate of emission. Furthermore the porosity of ceramic materials as well as of fired products influence the rate of emission. 10 refs. In German.

DESCRIPTORS: (*CERAMIC PLANTS, *Accident Prevention), FLUORINE, INDUSTRIAL POISONS,

IDENTIFIERS: FIRE CLAY

CARD ALERT: 803, 812, 914

16/3/1

1121160 ID NO.- EI810321160

UNTERSUCHUNGEN ZUM FLUORFREISLAUF BEIM BRAND IN DER GROBKERAMIK. \$left bracket\$ Investigations of Fluorine Emission during Firing in the Heavy Clay Industry \$right bracket\$.

Graetz, Reinhard

Inst fuer Ziegelforsch, Essen, Ger

Ber Dtsch Keram Ges v 57 n 3 Jun 1980 p 41-45 CODEN: BDKGAY

ISSN 0365-9542

16/3/2

848012 ID NO.- EI780748012

UEBER ANALYTISCHE FRAGEN BEI DER BESTIMMUNG VON FLUOR IN KERAMISCHEN WERKSTOFFEN. \$left bracket\$ Analytical Problems When Determining Fluorine in Ceramic Materials \$right bracket\$.

Schmidt, Helmut; Scholze, Horst

Fraunhofer-Ges, Wuerzburg, Ger

Ber Dtsch Keram Ges v 55 n 2 Feb 1978 p 79-82 CODEN: BDKGAY

16/3/3

774334 ID NO.- EI771074334

FLUORID-EMISSIONEN AUS ANLAGEN ZUM BRENNEN KERAMISCHER ERZEUGNISSE. \$left bracket\$ Fluoride Emission from Plants Designed for Firing Ceramics \$right bracket\$.

Bernert, J.; Schubert, P.

Wasser Luft Betr v 21 n 3 Mar 1977 p 122-124 CODEN: WSLBAF

16/3/4

740924 ID NO.- EI770640924

ERFAHRUNGEN MIT EMISSIONSMESSUNGEN IN DER KERAMISCHEN INDUSTRIE. \$left bracket\$ Emissions from Ceramic Kilns \$right bracket\$.

Jepsen, Klaus; Schmidt, Ernst

Ziegelforsch, Essen, Ger

Ber Dtsch Keram Ges v 54 n 1 Jan 1977 p 5-7 CODEN: BDKGAY

9/3/10

87089595 CA: 87(12)89595a JOURNAL

Fluoride - the central problem for the brick and tile industry in the sector of clean air

AUTHOR: Smidt, Harm

LOCATION: Cent. Div. Immission Prot., Tech. Supervision Assoc., Hanover, Ger.

JOURNAL: ZI Int. DATE: 1977 NUMBER: 4 PAGES: 165-9 CODEN: ZIIND7
LANGUAGE: English; German

9/3/11

86176225 CA: 86(24)176225s JOURNAL

Emission problems in the brick industry

AUTHOR: Berse, Helmut

LOCATION: Inst. Umweltschutz, Agrilulturchem., Vegetationsversuchsanst., Heiligenhaus, Ger.

JOURNAL: Staub - Reinhalt. Luft DATE: 1976 VOLUME: 36 NUMBER: 12
PAGES: 460-5 CODEN: STRH4V
LANGUAGE: German

19/3/9

96073820 CA: 96(10)73820. JOURNAL

Pollution of the environment by the emission of fluorine and its compounds

AUTHOR: Drahotinska, Marcela

LOCATION: Uniprojekt, Prague, Czech.

JOURNAL: Sklar Keram. DATE: 1981 VOLUME: 31 NUMBER: 10 PAGES: 293-5
CODEN: SKKEAO ISSN: 0037-637X LANGUAGE: Czech

9/3/1

91061627 CA: 91(8)61627d JOURNAL

Tests on fluorine behavior during the drying of green products in the brick and tile industry

Institut Fuer Ziegelforschung Essen e.V.

LOCATION: Essen, Fed. Rep. Ger.

JOURNAL: ZI Int. DATE: 1979 NUMBER: 4 PAGES: 227-9 CODEN:
ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

9/3/2

90173297 CA: 90(22)173297e JOURNAL

Fluorine loss in production of bricks and comparison with the loss in fluorine-bearing minerals

AUTHOR: Troll, G.; Farzaneh, A.

LOCATION: Inst. Mineral. Petrogr., Univ. Muenchen, Munich, Ger.

JOURNAL: Interceram DATE: 1978 VOLUME: 27 NUMBER: 4 PAGES:
400-2 CODEN: ITCRAC ISSN: 0020-5214 LANGUAGE: English

40/3/1

G6454E3 PB82-151242 NTIS Prices: PC A02/MF A01

Nu Tex Brick Plant, El Paso, Texas; Industrywide study

Craft, Bobby F.; Konzen, Richard B.

National Inst. for Occupational Safety and Health, Cincinnati, OH.

20 May 65 5p

Rept No: IWS-30.26

40/3/2

G6261K4 PB82-151226 NTIS Prices: PC A02/MF A01

Walk-through Industrial Hygiene Survey, Pine Hall Brick and Pipe Co.,
Madison, North Carolina 27025; Industrywide study

Donaldson, Harry M.; Wolf, Frances

National Inst. for Occupational Safety and Health, Cincinnati, OH.

12 Aug 75 5p

Rept No: IWS-30.17A

41/3/3

F0425G1 NP-23371 NTIS Prices: PC A05/MF A01

Energy Audit Series, No. 2, Building Brick Industry: Energy Conservation
and Utilization

Rose, K. S. B.

Department of Energy, London (England). *Department of Industry, London,
(England).

1977 88p

U.S. Sales Only.

41/3/10

E1654G3 CONF-770416-8 NTIS Prices: PC A02/MF A01

Energy Conservation in Periodic Kiln Operations Using Thermal Energy
Storage

Glenn, D. R.

Institute of Gas Technology, Chicago, Ill. *Department of Energy.

1977 22p

79. Annual meeting of American Ceramic Society, Chicago, IL, USA, 23 Apr
77.

9/3/2

9027717 CA: 97(4)27717d JOURNAL

Energy saving by heat recovery from the kiln exhaust air

AUTHOR: Jaenisch, K. Alwin

LOCATION: D-6507, Ingelheim/Rhein, Fed. Rep. Ger.

JOURNAL: ZI, Ziegellnd. Int. DATE: 1982 NUMBER: 3 PAGES: 187-8
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

9/3/10

77065890 CA: 77(10)65890z JOURNAL

Causes of tunnel kiln fluorine emission in brickyards and the possibility of sequestering it

AUTHOR: Beremann, Karl; Trojer, Felix

LOCATION: Inst. Gesteinshuettenkd. Feuerfeste Baustoffe, Montan. Hochsch., Leoben, Austria

JOURNAL: Zieselindustrie DATE: 1972 NUMBER: 5 PAGES: 234-40
CODEN: ZIEGAV LANGUAGE: German

9/3/11

77024373 CA: 77(4)24373a JOURNAL

Reduction of air-polluting fluoride emissions by pulverized hydrated lime

AUTHOR: Schmidt, Ernst

LOCATION: Inst. Ziegelforsch, Essen E. V., Essen, Ger.

JOURNAL: Zieselindustrie DATE: 1972 NUMBER: 3 PAGES: 120-34
CODEN: ZIEGAV LANGUAGE: German

16/3/3

96222527 CA: 96(26)222527y JOURNAL

Solution to a fluorine emission problem in stoneware production

AUTHOR: Tuenker, Gernard; Schmidt, Helmut

LOCATION: Fraunhofer-Inst. Silicatiforsch., D-8700, Wuerzburg, Fed. Rep. Ger.

JOURNAL: ZI, Zieselind. Int. DATE: 1982 NUMBER: 3 PAGES: 173-8
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

16/3/4

96222526 CA: 96(26)222526x JOURNAL

Determination of a production firing curve for optimum fluorine bonding in brick firing

AUTHOR: Koether, Wolfgang; Pauls, Norbert

LOCATION: D-4000, Duesseldorf, Fed. Rep. Ger.

JOURNAL: ZI, Zieselind. Int. DATE: 1982 NUMBER: 3 PAGES: 167-73
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

16/3/5

96128835 CA: 96(16)128835a JOURNAL

Reduction of fluoride emission by firing with lignite (brown coal) dust

AUTHOR: Schubert, P.

LOCATION: Kirchheim unter Teck, Fed. Rep. Ger.

JOURNAL: Keram. Z. DATE: 1982 VOLUME: 34 NUMBER: 1 PAGES: 23-4,
27 CODEN: KERZAS ISSN: 0023-0561 LANGUAGE: German

20/3/7

92115660 CA: 92(14)115660s JOURNAL

Reduction of environmental pollution by controlling the ceramic technological cycle

AUTHOR: Mazzali, P.; Orlandi, L.

LOCATION: Cent. Anti-Inquinamenti, Amministrazione Prov. Modena, Modena, Italy

JOURNAL: Ceramurgia DATE: 1979 VOLUME: 9 NUMBER: 5 PAGES: 235-9
CODEN: CERGIAR ISSN: 0047-6152 LANGUAGE: Italian

9/3/2

84008491 CA: 84(2)8491r JOURNAL

Possible methods for the control of fluoride emissions and information obtained from continuous measurements of fluoride in flue gas

AUTHOR: Gruetz, R.

LOCATION: Inst. Ziegelforsch. Essen e.V., Essen-Kray, Ger.

JOURNAL: Ziegelindustrie DATE: 1975 NUMBER: 4 PAGES: 130-8

CODEN: ZIEGAV LANGUAGE: German

9/3/3

83151321 CA: 83(18)151321v JOURNAL

Sulfur and fluorine cycle in tunnel kilns of the brickmaking industry

AUTHOR: Schmidt, Ernst

LOCATION: Inst. Ziegelforsch. Essen e.V., Essen, Ger.

JOURNAL: Gas Waerme Int. DATE: 1975 VOLUME: 24 NUMBER: 4 PAGES: 150-6

CODEN: GWINAT LANGUAGE: German

9/3/4

82063709 CA: 82(10)63709b JOURNAL

Measurement technique for fluorine emissions in a brickyard

AUTHOR: Hermann, P.

LOCATION: Rheinisch-Westfael. Tech. Ueberwachungsver. e.V., Essen, Ger.

JOURNAL: Gesund.-Ing. DATE: 1974 VOLUME: 95 NUMBER: 9 PAGES: 263-7

CODEN: GEINAS LANGUAGE: German

9/3/5

81110788 CA: 81(18)110788t JOURNAL

Compilation of measured data on fluoride emission in brickworks

AUTHOR: Hermann, Peter

LOCATION: Rheinisch-Westfael. Tech. Ueberwachungsverein e. V., Essen, Ger.

JOURNAL: Ziegelindustrie DATE: 1974 NUMBER: 4 PAGES: 148-51

CODEN: ZIEGAV LANGUAGE: German

9/3/6

81110733 CA: 81(18)110733w JOURNAL

Current practice for the reduction of fluoride emission in the brick and tile industries by scrubbing of the flue gases

AUTHOR: Huenlich, Hans W.

LOCATION: Doenbers, Ger.

JOURNAL: Ziegelindustrie DATE: 1974 NUMBER: 4 PAGES: 155-62

CODEN: ZIEGAV LANGUAGE: German

9/3/7

80148724 CA: 80(26)148724v JOURNAL

Continuous monitoring of fluoride emission

AUTHOR: Kassebeer, Gerd

LOCATION: Ger.

JOURNAL: Ziegelindustrie DATE: 1973 NUMBER: 10 PAGES: 356-9

CODEN: ZIEGAV LANGUAGE: German

9/3/8

80112067 CA: 80(20)112067v JOURNAL

Is a solution to the fluorine emission problem of the brick industry in sight

AUTHOR: Schmidt, Ernst

LOCATION: Inst. Ziegelforsch. Essen e. V., Essen, Ger.

JOURNAL: Luftverunreinigung DATE: 1973 PAGES: 38-46 CODEN: LFTVAA

LANGUAGE: German

9/3/7

92202607 CA: 92(24)202607p JOURNAL
Measures for the prevention of air pollution in brick and tile production
AUTHOR: Kolkmeier, H.
LOCATION: Fed. German Assoc. Brick and Tile Ind. Resd., Bonn, Fed. Rep.
Ger.
JOURNAL: ZI Int. DATE: 1979 NUMBER: 11 PAGES: 670-4 CODEN:
ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

16/3/1

95208754 CA: 95(24)208754t JOURNAL
Emission and abatement of fluorinated compounds in the glass industry
AUTHOR: Capodaglio, Gabriele; Russo, Umberto; Zanin, Secondo; Moret, Ivo;
Scarponi, Giuseppe
LOCATION: Ist. Chim. Gen. Inorg., Univ. Venezia, I-30123, Venice, Italy
JOURNAL: Ann. Chim. (Rome) DATE: 1981 VOLUME: 71 NUMBER: 7-8
PAGES: 413-23 CODEN: ANCRAI ISSN: 0003-4592 LANGUAGE: English

9/3/7

88157734 CA: 88(22)157734s JOURNAL
Design and testing of a plant for the dry sorption of fluoride compounds
from the waste gas of a brick kiln with subsequent dedusting
AUTHOR: Jepsen, K.; Sendatzki, M.
LOCATION: Chem. Div., Brick Tile Res. Inst., Essen, Ger.
JOURNAL: ZI Int. DATE: 1977 NUMBER: 10 PAGES: 480-91 CODEN:
ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

16/3/11

93052782 CA: 93(6)52782w JOURNAL
Effect of the design of the furnace on the emission of fluorine
AUTHOR: Graetz, Reinhard
LOCATION: Essen, Fed. Rep. Ger.
JOURNAL: Sprechsaal DATE: 1980 VOLUME: 113 NUMBER: 1 PAGES:
25-6, 30-3 CODEN: SPREAS ISSN: 0341-0439 LANGUAGE: German

16/3/8

94108377 CA: 94(14)108377h JOURNAL
Characterization of the fluorine emission of pottery
AUTHOR: Schmidt, Helmut; Scholze, Horst
LOCATION: Fraunhofer-Inst. Silicidforsch., D-8700, Wuerzburg, Fed. Rep.
Ger.
JOURNAL: Ber. Dtsch. Keram. Ges. DATE: 1980 VOLUME: 57 NUMBER: 3
PAGES: 49-52 CODEN: BDKGAY ISSN: 0365-9542 LANGUAGE: German

16/3/9

94108376 CA: 94(14)108376s JOURNAL
Possibilities of reducing the emission of fluorine in the ceramic
industry
AUTHOR: Hartinger, Hannes
LOCATION: D-8472, Schwarzenfeld, Fed. Rep. Ger.
JOURNAL: Ber. Dtsch. Keram. Ges. DATE: 1980 VOLUME: 57 NUMBER: 3
PAGES: 4*-5 CODEN: BDKGAY ISSN: 0365-9542 LANGUAGE: German

16/3/6

94126579 CA: 94(16)126579e JOURNAL
Effect of the kiln system on fluorine emission
AUTHOR: Graetz, Reinhard
LOCATION: Essen, Fed. Rep. Ger.
JOURNAL: TIZ DATE: 1980 VOLUME: 104 NUMBER: 8 PAGES: 522, 524-8
CODEN: TTZED8 ISSN: 0170-0146 LANGUAGE: German

16/3/6

96073820 CA: 96(10)73820 JOURNAL

Pollution of the environment by the emission of fluorine and its compounds

AUTHOR: Drahotinska, Marcela

LOCATION: Uniprjekt, Prague, Czech.

JOURNAL: Sklar Keram. DATE: 1981 VOLUME: 31 NUMBER: 10 PAGES: 293-5
CODEN: SKKEAQ ISSN: 0037-637X LANGUAGE: Czech

51/3/1

81-03508

Industrial Air Pollution: British Progress - A Review
Nonhebel, G.

18 Dunnings Lane, Southampton, Engl.

ATMOS. ENVIRON. VOL. 15, NO. 3, pp. 213-219, Publ.Yr: 1981

16/3/4

95137489 CA: 95(16)137489 JOURNAL

Fluoride pollution around tile works. Effects of a single source on environment

AUTHOR: Nakao, Makoto; Tanaka, Fumio; Tachibana, Chikao; Fukada, Kazumi; Hayashi, Kyoichi; Saito, Koichi

LOCATION: Shimane Prefect. Inst. Public Health Environ. Sci., Japan

JOURNAL: Zenkoku Kosaiken Kaishi DATE: 1980 VOLUME: 5 NUMBER: 2
PAGES: 105-15 CODEN: ZKKADQ ISSN: 0385-1028 LANGUAGE: Japanese

9/5/3

930413 ID NO.- EI790530413

PHYTOTOXICOLOGY FLUORIDE STUDIES IN ONTARIO.

Linzon, Samuel N.

Ont Minist of the Environ, Ottawa

Proc Ont Ind Waste Conf 25th, Toronto, Ont, Jun 18-21 1978. Publ by Ont
Minist of Environ, Ottawa, 1978 p 105-121 CODEN: OIWPAP

ISSN 0078-4893

With regard to fluorides, several kinds of industries are under investigation which have the potential to affect vegetation in Ontario. These industries include manufacturers of phosphate fertilizers, hydrofluoric acid, fiberglass, steel, uranium hexafluoride, petroleum products, brick, ceramic, frit, glass, and aluminum. There is considerable variability in response to atmospheric fluorides by various plant species and varieties. When fluorides accumulate in plant leaves beyond certain threshold levels, which varies with different plant species, leaf injuries occur. Farm animals may develop the disease fluorosis by feeding on fluoride-contaminated forage crops over an extended period of time. The paper presents results of some fluoride investigations conducted in Ontario during the past 10 years.

DESCRIPTORS: (*AIR POLLUTION, *Environmental Impact), FLUORINE COMPOUNDS,
IDENTIFIERS: FLUORIDES, PHYTOTOXICOLOGY

CARD ALERT: 451, 804, 821

10/5/7

134930 *79-002292

INQUINAMENTO DA PIOMBO E FLUORO NEL COMPRESORIO DELLA CERAMICHE POSSIBILI EFFETTI SULLA SALUTE DEGLI ABITANTI DELLA ZONA,

OLIVO. R. ; VIVOLI G. ; PINI A. ; BORELLA P. ; CASELGRANDI E. ; PREDIERI G.

UNIVERSITA DI MODENA, ITALY,

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF, BOLOGNA, JAN 26-27, 78, P3 (56)

RESEARCH REPORT: PRESENTED ARE AVAILABLE DATA CONCERNING THE EFFECTS OF LEAD AND FLUORINE EMISSIONS FROM THE CERAMIC INDUSTRY IN SASSUOLO, ITALY, ON SURFACE WATERS, AIR, AND FOODSTUFFS OF THE SURROUNDING AREA. DATA SHOW THAT ENVIRONMENTAL POLLUTION IN THE DISTRICT HAS REACHED CRITICAL LEVELS, FAR EXCEEDING THE LIMITS SET BY GOVERNMENTAL REGULATIONS. POSSIBLE EFFECTS OF ENVIRONMENTAL POLLUTION ON HUMAN HEALTH ARE EXAMINED. ALTHOUGH FLUORINE POLLUTION SEEMS TO BE HAVING NO SIGNIFICANT EFFECT ON HUMAN HEALTH, HIGH LEAD CONCENTRATIONS FOUND IN BLOOD AND URINE SAMPLES OF CHILDREN AND ADULTS ARE ASSOCIATED WITH INTERFERENCES IN PORPHYRIC METABOLISM. (IN ITALIAN) (NUMEROUS DIAGRAMS, GRAPHS, REFERENCES, TABLES)

DESCRIPTORS: *CONF PAPER ; *LEAD ; *FLUORINE ; *BIOLOGY, HUMAN ; *ITALY ; *AIR QUALITY STANDS ; HEALTH, ENV ; *325-6 CLAY-POTTERY PRODUCTS

REVIEW CLASSIFICATION: 02

10/5/8

134802 *79-002164

STACK EMISSION CONTROL TECHNOLOGIES,

WILSON H. H.

CLEMSON UNIV.

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF, BOLOGNA, JAN 26-27, 78, P306 (6)

SURVEY REPORT: U.S. NATIONAL AIR POLLUTION REGULATIONS AND AMBIENT AIR QUALITY STANDARDS AFFECTING THE CERAMIC INDUSTRY ARE EXAMINED. SOURCES OF POLLUTION-PARTICULARLY LEAD AND FLUORINE-FROM THE CERAMIC INDUSTRY ARE IDENTIFIED. CURRENT TECHNOLOGICAL AND REGULATORY ALTERNATIVES FOR CONTROLLING LEAD AND FLUORINE EMISSIONS ARE DESCRIBED. POLLUTION CONTROL METHODS CURRENTLY BEING IMPLEMENTED IN THE U.S. INCLUDE: A PACKED TOWER SCRUBBER; A VENTURI SCRUBBER; AND ELECTROSTATIC PRECIPITATORS. (17 REFERENCES)

DESCRIPTORS: *STACK EMISSION CONTROL ; *AIR QUALITY STANDS, SOURCE ; *PARTICULATE SIZE ; *FLUORINE ; *LEAD ; *SCRUBBERS, WET ; *ELECTROSTATIC PRECIPITATORS ; CONF PAPER ; HYDROCARBONS-AIR ; SULFATES

REVIEW CLASSIFICATION: 01

10/5/9

134801 *79-002163

EFFETTI DEL FLUORO NEL SETTORE ZOOTECNICO,

GENTILE G.

UNIV OF MILAN, ITALY,

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF, BOLOGNA, JAN 26-27, 78, P59 (20)

RESEARCH REPORT: EFFECTS OF FLUORINE EMISSIONS FROM INDUSTRIAL SOURCES ON DOMESTIC ANIMALS ARE DESCRIBED. CLINICAL ASPECTS OF CHRONIC FLUOROSIS (WHICH RESULTS FROM SLOW AND PROLONGED ASSIMILATION OF SMALL AMOUNTS OF FLUORINE THROUGH THE DIGESTIVE SYSTEM) ARE REVIEWED. FODDER FOUND NEAR CERAMIC FOUNDRIES IS KNOWN TO CONTAIN DANGEROUSLY HIGH LEVELS OF FLUORINE. AVERAGE FLUORINE CONTENT OF FODDER IN POLLUTED AREAS IS 114.7 PPM; IN NONPOLLUTED AREAS, FLUORINE CONTENT IN FODDER IS 5.8 PPM. (IN ITALIAN) (41 REFERENCES)

DESCRIPTORS: *FLUORINE ; *PATHOLOGY, ANIMAL ; *CATTLE ; *AIR POLLUTION DAMAGE ; FEED CONTAMINATION ; ATMOSPHERIC POLLUTANT DEPOSITION ; CONF PAPER ; HEALTH SAFETY, OCCUPATIONAL ; ITALY ; *325-6 CLAY-POTTERY PRODUCTS

REVIEW CLASSIFICATION: 01

10/5/2

134935 *79-002297

LA QUALITA DELL'ARIA IN RAPPORTO ALLE EMISSIONI,

CORRADI, A. ; NUCCIOTTI F.

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF. BOLOGNA, JAN 26-27, 78, P335 (10)

RESEARCH REPORT: AIR POLLUTION LIMITS SET FORTH BY THE ITALIAN GOVERNMENT TO CONTROL LEAD AND FLUORINE EMISSIONS WERE REVIEWED. TWO AREAS IN ITALY WERE STUDIED: THE CERAMIC INDUSTRY DISTRICT IN SASSUOLO AND THE SANTERNO VALLEY IN THE IMOLA DISTRICT. THOUGH FLUORINE AND LEAD EMISSIONS DID NOT EXCEED LEGAL LIMITS IN EITHER AREA, THERE WAS CONSIDERABLE ENVIRONMENTAL DEGRADATION IN BOTH. POLLUTION IMPACTS ON HUMAN HEALTH, ANIMALS, AND AGRICULTURE WERE ALSO NOTED. IT IS SUGGESTED THAT THE EXISTING POLLUTION EMISSION LIMITS ARE TOO LENIENT AND ARE, THEREFORE, INADEQUATE TO PROTECT AIR QUALITY, HUMAN HEALTH, ANIMALS, AND AGRICULTURE. (IN ITALIAN) (1 MAP, 8 REFERENCES)

DESCRIPTORS: *LEAD ; *FLUORINE ; *AIR POLLUTION EFFECTS ; *AIR QUALITY STANDS ; *ITALY ; HEALTH, ENV ; CONF PAPER
REVIEW CLASSIFICATION: 02

10/5/3

134934 *79-002296

ATTUALI ORIENTAMENTI SUI LIMITI ALLE IMMISSIONI DI INQUINANTI ATMOSFERICI.

MONTERIOLO, S. CERQUIGLINI ; GATTI G. L.

ISTITUTO SUPERIORE SANITA, ROME.

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF. BOLOGNA, JAN 26-27, 78, P325 (10)

RESEARCH REPORT: MAXIMUM LIMITS IMPOSED BY VARIOUS INDUSTRIALIZED NATIONS ON LEAD AND FLUORINE EMISSIONS FROM INDUSTRIAL SOURCES ARE REVIEWED AND ARE COMPARED WITH LIMITS IMPOSED BY ITALIAN LAW. IT IS DEMONSTRATED THAT THE EMISSION LIMITS IN ITALY ARE FAR MORE LENIENT THAN THOSE IN MOST OTHER DEVELOPED NATIONS. PROSPECTS FOR MODIFICATION OF ITALIAN EMISSION LIMITS ARE DISCUSSED. (IN ITALIAN) (8 REFERENCES, 4 TABLES)

DESCRIPTORS: *LEAD ; *FLUORINE ; *AIR QUALITY STANDS, SOURCE ; *ITALY ; *LAW, ENV-NON U S ; STACK EMISSIONS ; HEALTH, ENV ; AREA COMPARISONS ; CONF PAPER

REVIEW CLASSIFICATION: 02

10/5/4

134933 *79-002295

LEAD POLLUTION IN WORKROOM ENVIRONMENTS.

HERNBERG S.

HELSINKI INST OF OCCUPATIONAL HEALTH, FINLAND.

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF. BOLOGNA, JAN 26-27, 78, P203 (10)

RESEARCH REPORT: ALTHOUGH WORKERS IN INDUSTRIALIZED CERAMIC FACTORIES ARE (IN GENERAL) NO LONGER EXPOSED TO DANGEROUSLY HIGH LEAD EMISSIONS, THE PROBLEM OF LEAD EXPOSURE IS STILL PREVALENT IN SMALLER FACTORIES, ESPECIALLY IN DEVELOPING NATIONS. EXPOSURE TO HIGH LEVELS OF LEAD CAN LEAD TO ANEMIA AND DISORDERS OF THE CENTRAL AND PERIPHERAL NERVOUS SYSTEMS. TECHNIQUES FOR MONITORING CERAMICS WORKERS FOR EXPOSURE TO LEAD EMISSIONS ARE DESCRIBED. ALTERNATIVE STRATEGIES FOR PREVENTING LEAD EXPOSURE INCLUDE ELIMINATING UNNECESSARY USE OF LEAD DURING GLAZING OPERATIONS; SUBSTITUTING LESS TOXIC AGENTS; PREVENTING THE SPREAD OF DUST AND FUMES; REMOVING EXISTING LEAD FROM THE FACTORY; AND REDUCING WORKER CONTACT WITH LEAD. (8 REFERENCES)

DESCRIPTORS: *LEAD ; *HEALTH SAFETY, OCCUPATIONAL ; *AIR POLLUTION, INDOOR ; MONITORING, ENV-AIR ; CONF PAPER ; *325-6 CLAY-POTTERY PRODUCTS
REVIEW CLASSIFICATION: 02

10/5/5

134932 *79-002294

EFFECTS OF LEAD AND FLUORINE ON AGRICULTURE.

HOUTEN J. G. TEN

AGRICULTURAL UNIV. WAGENINGEN, NETHERLANDS.

PRESENTED AT CENTRO CERAMICO PROBLEMS OF LEAD & FLUORINE AIR POLLUTION FROM INDUSTRIAL SOURCES INTL CONF. BOLOGNA, JAN 26-27, 78, P119 (9)

SURVEY REPORT: PRESENTED ARE AVAILABLE DATA ON THE EFFECTS OF LEAD AND FLUORINE EMISSIONS ON PLANTS. LEAD DOES NOT INDUCE SPECIAL TYPES OF EASILY RECOGNIZABLE INJURY IN PLANTS. AT HIGH SOIL CONCENTRATIONS OF LEAD, PLANTS RESPOND WITH REDUCED GROWTH AND LOWERED CROP YIELDS. IT IS DIFFICULT TO ASCERTAIN THE EFFECTS OF ATMOSPHERIC LEAD ON PLANTS. FLUORINE, IN CONTRAST TO LEAD, IS EXTREMELY TOXIC TO PLANTS. HAZARDS TO VEGETATION COME MAINLY FROM DIRECT ACTION OF GASEOUS FLUORIDE COMPOUNDS ON ABOVE-GROUND PLANT PARTS. CHLOROSIS OR NECROSIS OF PLANT LEAVES EXPOSED TO FLUORINE IS COMMON. THE USE OF THE MOST SENSITIVE PLANT SPECIES AS BIOLOGICAL INDICATORS OF HIGH LEVELS OF ATMOSPHERIC FLUORINE IS DISCUSSED. (36 REFERENCES)

DESCRIPTORS: *LEAD ; *FLUORINE ; *PATHOLOGY, PLANT ; *CROP DAMAGE ; *SOIL CONTAMINATION ; CONF PAPER ; BIOLOGICAL INDICATORS-AIR

REVIEW CLASSIFICATION: 02

16/5/2

848012 ID NO.- EI780748012

UEBER ANALYTISCHE FRAGEN BEI DER BESTIMMUNG VON FLUOR IN KERAMISCHEN WERKSTOFFEN. \$left brackets\$ Analytical Problems When Determining Fluorine in Ceramic Materials \$right brackets\$.

Schmidt, Helmut; Scholze, Horst

Fraunhofer-Ges, Wuerzburg, Ger

Ber Dtsch Keram Ges v 55 n 2 Feb 1978 p 79-82 CODEN: BDKGAY

Determination of F in the solid material presents problems if the F contents are extremely small (due to spurious effects from the apparatus). Continuous waste gas analysis, which makes it possible to set up an emission profile of a ceramic product, can only proceed gradually. The quality of analytical determinations depends very much on the tube material of the furnace. Whilst ceramic materials exhibit memory effects, these can be obviated by using platinum. 11 refs. In German with English abstract.

DESCRIPTORS: (*CERAMIC MATERIALS, *Analysis),

CARD ALERT: 812

16/5/1

1121160 ID NO.- EI810321160

UNTERSUCHUNGEN ZUM FLOURKREISLAUF BEIM BRAND IN DER GROBKERAMIK. \$left brackets\$ Investigations of Fluorine Emission during Firing in the Heavy Clay Industry \$right brackets\$.

Graetz, Reinhard

Inst fuer Ziegelforsch, Essen, Ger

Ber Dtsch Keram Ges v 57 n 3 Jun 1980 p 41-45 CODEN: BDKGAY

ISSN 0365-9542

Fluorine may be retained at relatively low temperature if the exhaust gases from the kiln pass through bed of lime. At temperatures up to 1000 \$degrees\$ C the emission of fluorine from well crystallized fluoride is considerably less than its dissociation from the clay mineral lattice. In production practice therefore the aim should be the formation of well crystallized fluoride. 6 refs. In German with English abstract.

DESCRIPTORS: (*CLAY PRODUCTS, *Manufacture), (AIR POLLUTION, Control),

CARD ALERT: 812, 451

83065007 CA: 83(8)65007r JOURNAL
Atmospheric contamination caused by the ceramic industry.
Preliminary data
AUTHOR: Vivoli, G.; Ferrari, L.; Manicardi, G.; Olivo, R.
LOCATION: Ist. Ig., Univ. Modena, Modena, Italy
JOURNAL: Ann. Sanita Pubblica DATE: 1973 VOLUME: 32
NUMBER: 6, Suppl., Atti Congr. Naz. Ig., 26th, 1971, Vol. 1
PAGES: 367-71 CODEN: ADSAAB LANGUAGE: Italian

83047518 CA: 83(6)47518d JOURNAL
Fluorine emission from ceramic firing processes
AUTHOR: Wilson, H. H.
LOCATION: Environ. Prot. Agency, Natl. Environ. Res. Cent.,
Research Triangle Park, N. C.
JOURNAL: J. Aust. Ceram. Soc. DATE: 1974 VOLUME: 10
NUMBER: 3 PAGES: 53-5 CODEN: JAUCA3 LANGUAGE: English

82159879 CA: 82(24)159879h JOURNAL
Atmospheric pollution caused by ceramics factories in the
area of Sassuolo and Fionano, and its effect on health
AUTHOR: Olivo, R.; Vivoli, G.; Rinaldi Ferrari, L.; Vecchi,
G.
LOCATION: Ist. Ig., Univ. Modena, Modena, Italy
JOURNAL: Ann. Sanita Pubblica DATE: 1974 VOLUME: 35
NUMBER: 4 PAGES: 265-312 CODEN: ADSAAB LANGUAGE:
Italian

82115587 CA: 82(18)115587g CONFERENCE PROCEEDING
Control of atmospheric emissions from glass manufacture
AUTHOR: Yamamoto, H.; Uchino, T.
LOCATION: Asahi Glass Co., Ltd., Tokyo, Japan
JOURNAL: Int. Congr. Glass. (Pap.), 10th DATE: 1974
VOLUME: 4, PAGES: 42-51 CODEN: 290BAB LANGUAGE:
English MEETING DATE: 74 PUBLISHER: Ceram. Soc. Jpn.,
Tokyo, Japan

82063773 CA: 82(10)63773t JOURNAL
Determination of fluorine in glass industry fumes
AUTHOR: Russo, U.; Zanin, S.; Cescon, P.
LOCATION: Fac. Chim. Ind., Univ. Venezia, Venice, Italy
JOURNAL: Inquinamento DATE: 1974 VOLUME: 16 NUMBER: 9
PAGES: 21-3 CODEN: IQAAAW LANGUAGE: Italian

93172849 CA: 93(18)172849v JOURNAL
Fluoride pollution around tile factories. 2
AUTHOR: Kamaya, Takeshi; Tateishi, Hiroko; Honda, Kunitaka
LOCATION: Nagasaki Prefect. Inst. Public Health Environ.
Sci., Nagasaki, Japan
JOURNAL: Nagasaki-ken Eisei Kogai Kenkyusho Ho DATE: 1979
VOLUME: 19, PAGES: 45-51 CODEN: NKHODN LANGUAGE:
Japanese MEETING DATE: 78

93078652 CA: 93(8)78652d JOURNAL
Ionizing Wet Scrubber keeps Globe Refractories in compliance
AUTHOR: Jeffers, P. E.
LOCATION: USA
JOURNAL: Brick Clay Rec. DATE: 1980 VOLUME: 176
NUMBER: 3 PAGES: 18-21 CODEN: BRCRAM ISSN: 0006-9760
LANGUAGE: Italian

Fluorine loss in the baking of enamel
AUTHOR: Van der Rhee, A. K.
LOCATION: Ger.
JOURNAL: Mitt. Ver. Dtsch. Emailfachleute DATE: 1978
VOLUME: 26 NUMBER: 4 PAGES: 46-55 CODEN: MVDEA2
ISSN: 0042-3823 LANGUAGE: German

89079396 CA: 89(10)79396c JOURNAL
Fluoride emission in the kiln firing of refractory clays to
chamotte (grog)
AUTHOR: Routschka, Gerald; Majdic, Aleksander
LOCATION: Res. Inst. Refract. Ind., Bonn, Ger.
JOURNAL: ZI Int. DATE: 1978 NUMBER: 1 PAGES: 6-15
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

92152233 CA: 92(18)152233r JOURNAL
Problems with lead and fluorine as pollutants in the
ceramics industry
AUTHOR: Palmonari, C.; Timellini, G.; Bacchilega, B.
LOCATION: Cent. Ceram., Bologna, Italy
JOURNAL: Ind. Cnram. DATE: 1979 VOLUME: 731, PAGES:
589-93 CODEN: IDCQAX ISSN: 0019-9044 LANGUAGE: French

83047518 CA: 83(6)47518d JOURNAL
Fluorine emission from ceramic firing processes
AUTHOR: Wilson, H. H.
LOCATION: Environ. Prot. Agency, Natl. Environ. Res. Cent.,
Research Triangle Park, N. C.
JOURNAL: J. Aust. Ceram. Soc. DATE: 1974 VOLUME: 10
NUMBER: 3 PAGES: 53-5 CODEN: JAUCA3 LANGUAGE: English

82159879 CA: 82(24)159879h JOURNAL
Atmospheric pollution caused by ceramics factories in the
area of Sassuolo and Fiorano, and its effect on health
AUTHOR: Olivo, R.; Vivoli, G.; Rinaldi Ferrari, L.; Vecchi,
G.
LOCATION: Ist. Ig., Univ. Modena, Modena, Italy
JOURNAL: Ann. Sanita Pubblica DATE: 1974 VOLUME: 35
NUMBER: 4 PAGES: 265-312 CODEN: ADSAAB LANGUAGE:
Italian

88196196 CA: 88(26)196196c JOURNAL
Studies on the behavior of fluoride in the firing of
refractory clays
AUTHOR: Routschka, Gerald; Majdic, Aleksander
LOCATION: Forschungsinst. Feuerfest-Ind., Bonn, Ger.
JOURNAL: ZI Int. DATE: 1978 NUMBER: 2 PAGES: 76-86
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

83201497 CA: 83(24)201497e JOURNAL
Determination of small fluoride contents in solids and in
gaseous emissions
AUTHOR: Hermann, Peter
LOCATION: Rheinisch-Westfael. Tech. Ueberwachungs-Ver. e.V.,
Essen, Ger.
JOURNAL: Ziegelindustrie DATE: 1975 NUMBER: 4 PAGES:
142-5 CODEN: ZIEGAV LANGUAGE: German

822939 ID NO. - EI780422939

DIE BESTIMMUNG FEINSTER LUFTVERUNREINIGUNGEN, INSBESONDERE VON FLUOR UND SCHWEFELVERBINDUNGEN. \$left brackets Detection of Pollutant Traces, Particularly of Fluorine and Sulfur Compounds \$right brackets

Radczewski, O. E.

Keram Z v 29 n 12 Dec 1977 p 669-672 CODEN: KERZAS

This article treats shortly importance and occurrence of fluorine instead of (OH) in minerals and raw materials as well as the fluorine content of air, rain-water and plants. It can be chemically proved in smallest quantities but the bond type cannot be determined. This is possible with electronic microscopy and diffraction on individual crystalline particles. Results from aluminum works as well as heavy clay and fine ceramic manufactories are given whereby also characteristic compounds for certain emitted particles were found. 9 refs. in German with English abstract.

DESCRIPTORS: (-AIR POLLUTION, *Analysis).

CARD ALERT: 45' 341

94126232 CA: 94(16)126232m JOURNAL

Fluorine determination in ceramic raw materials and products and measurement of gaseous inorganic fluorine compounds

AUTHOR: Hermann, Peter

LOCATION: Rheinisch-Westfael. Tech. Ueberwach.-Verein e.V., D-4300, Essen, Fed. Rep. Ger.

JOURNAL: Ber. Dtsch. Keram. Ges. DATE: 1980 VOLUME: 57

NUMBER: 3 PAGES: 36-40 CODEN: BDKGAY ISSN:

0365-9542 LANGUAGE: German

94126201 CA: 94(16)126201a JOURNAL

Effect of temperature and calcium and magnesium on fluorine release in ceramic tiles firing

AUTHOR: Mazzali, P.; Fogliani, G.; Orlandi, L.; Busani, G.

LOCATION: Cent. Antinquinamento, Modena, Italy

JOURNAL: Ceramica (Florence) DATE: 1980 VOLUME: 33

NUMBER: 2 PAGES: 1-6 CODEN: CERMA3 ISSN: 0366-5801

78-03123

Fluoride pollution caused by a brickworks in the Flemish countryside of Belgium.

Debackere, M.; Delbeke, F. T.

Laboratorium voor Farmacologie en Toxicologie der Huisdieren, Faculteit Diergeneeskunde, Rijksuniversiteit Gent, Casinoplein 24 B-3000 Gent, Bel.

INTERNATIONAL JOURNAL OF ENVIRONMENTAL STUDIES 11(4),

245-252, Coden: IJEVAV Publ.Yr: 1978

illus. refs. (Some in Du.; Ger.)

Abs.

72-06119 72-5TA-01068

Fluorine contents of air and plants in the vicinity of a brick works.

OELSCHLAEGER, WALTER

Universitaet Hohenheim, Institut fuer Tierernaehrung, Landes-Institut fuer Arbeitsschutz und Arbeitsmedizin Karlsruhe, Ger.

Staub-Reinhaltung der Luft, 31(5):29-31, May 1971 Publ.Yr: 1971

89079336 CA: 89(10)79336h JOURNAL

Ideas and suggestions for the establishment of fluoride emission values and chimney heights for the heavy clay industry

AUTHOR: Smidt, Harm

LOCATION: Cent. Div. Immission Prot., Tech. Supervision Assoc., Hanover, Ger.

JOURNAL: ZI Int DATE: 1978 NUMBER: 4 PAGES: 177-89

CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

95137508 CA: 95(16)137508c JOURNAL
Fluorine-containing flue gases from brickworks, and their
impact upon vegetation
AUTHOR: Boertitz, S.; Reuter, F.
LOCATION: Sekt. Forstwirtschaft, Tech. Univ. Dresden, Tharandt
Ger. Dem. Rep.
JOURNAL: Luft- Kältetechnik. DATE: 1980 VOLUME: 16
NUMBER: 4 PAGES: 180-2 CODEN: LUKAA7 ISSN: 0024-7251
LANGUAGE: German

91198104 CA: 91(24)198104g JOURNAL
Possible reduction of pollutant emission in sewer stoneware
production
AUTHOR: Hoffmann, B.
LOCATION: VEB Ver. Steinzeugwerke, Bad Schmiedeberg, Ger.
Dem. Rep.
JOURNAL: Baustoffindustrie, Ausg. A DATE: 1979 VOLUME:
22 NUMBER: 3 PAGES: 21-2 CODEN: RIDAEN ISSN:
0323-4886 LANGUAGE: German

91128170 CA: 91(16)128170b JOURNAL
Fluoride pollution around a tile factory
AUTHOR: Kamaya, Takeshi; Honda, Kunitaka
LOCATION: Nagasaki-ken Inst. Public Health Environ. Sci.,
Nagasaki, Japan
JOURNAL: Nagasaki-ken Eisai Kogai Kenkyusho Mo DATE: 1978
VOLUME: 17, PAGES: 48-52 CODEN: NKHOON LANGUAGE:
Japanese MEETING DATE: 77

81175256 CA: 81(26)175256n JOURNAL
Fluoride in ceramic materials and fuels. Provision of
materials for the prevention of fluoride emission
AUTHOR: Graetz, Reinhard
LOCATION: Inst. Ziegelforsch. Essen e.V., Essen-Kray, Ger.
JOURNAL: Ziegelindustrie DATE: 1974 NUMBER: 4 PAGES:
164-8; (5). 210-16 CODEN: ZIEGAV LANGUAGE: German

91111724 CA: 91(14)111724n JOURNAL
Emission control measures and their development in the
ceramic industry
AUTHOR: Liesegang, Engr D.
LOCATION: Berlin, Fed. Rep. Ger.
JOURNAL: ZI Int. DATE: 1979 NUMBER: 4 PAGES: 224-7
CODEN: ZIIND7 ISSN: 0341-0552 LANGUAGE: English; German

94126600 CA: 94(16)126600e JOURNAL
Absorptive dry hot-cleaning of waste gases in the ceramic
industry
AUTHOR: Rasch, R.
LOCATION: Heppenheim, Fed. Rep. Ger.
JOURNAL: Keram. Z. DATE: 1980 VOLUME: 32 NUMBER: 7
PAGES: 376-8 CODEN: KERZAS ISSN: 0023-0561 LANGUAGE:
German

82034552 CA: 82(6)34552q JOURNAL
Mode of action for the decrease of emissions in tile works
AUTHOR: Winkler, H. D.
LOCATION: Landesamt Emiss. Bodennutz. Landes
Nordrhein-Westfalen, Essen/Bredene, Ger.
JOURNAL: Gesund.-Ing. DATE: 1974 VOLUME: 95 NUMBER: 9
PAGES: 267-71 CODEN: GEINAS LANGUAGE: German

83208951 CA: 83(26)208951g JOURNAL
Modification of existing tunnel kilns can save energy, cut
heat loss
AUTHOR: Hicks, Terrill G.
LOCATION: Babcock and Wilcox Co., Augusta, Ga.
JOURNAL: Am. Ceram. Soc., Bull. DATE: 1975 VOLUME: 54
NUMBER: 9 PAGES: 797-8 CODEN: ACSBA7 LANGUAGE:
English

96034568 CA: 96(6)39568y JOURNAL
New developments in the energy saving application of
refractories in industrial furnaces - a literature survey
AUTHOR: Routschka, G.; Majdic, A.
LOCATION: Forschungsinst., Feuerfest-Ind., Bonn, Fed. Rep.
Ger.
JOURNAL: Keram. Z. DATE: 1981 VOLUME: 33 NUMBER: 9
PAGES: 511-22, 538 CODEN: KERZAS ISSN: 0023-0561
LANGUAGE: German

92081393 CA: 92(10)81393e JOURNAL
Results of an environmental air study of fluoride pollution
AUTHOR: Nakao, Makoto; Tanaka, Fumio
LOCATION: Shimane Prefect. Inst. Public Health Environ. Sci.,
Matsue, Japan
JOURNAL: Shimane-ken Eisei Kogai Kenkyusho Ho DATE: 1977
VOLUME: 19, PAGES: 152-7 CODEN: SEH002 LANGUAGE:
Japanese

92081391 CA: 92(10)81391c JOURNAL
Air pollution by fluorides near a tile plant. Results of an
environmental study using gladiolus
AUTHOR: Nakao, Makoto; Tanaka, Fumio
LOCATION: Shimane Prefect. Inst. Public Health Environ. Sci.,
Matsue, Japan
JOURNAL: Shimane-ken Eisei Kogai Kenkyusho Ho DATE: 1977
VOLUME: 19, PAGES: 146-8 CODEN: SEH002 LANGUAGE:
Japanese

91111839 CA: 91(14)111839d JOURNAL
The ceramic industrial district of Sassuolo (Italy).
Preliminary results of a study on atmospheric pollution. Part
II
AUTHOR: Palmonari, C.; Nucciolotti, F.; Timellini, G.;
Sacchilega, B.
LOCATION: Cent. Ceram., Bologna, Italy
JOURNAL: Ceramica (Florence) DATE: 1976 VOLUME: 29
NUMBER: 6 PAGES: 9-14 CODEN: CERNAJ ISSN: 0366-5801
LANGUAGE: Italian

94108344 CA: 94(14)108344v JOURNAL
Some observations on atmospheric fluoride concentrations in
Stoke-on-Trent (United Kingdom)
AUTHOR: Bennett, A. J.; Barratt, R. S.
LOCATION: Stoke-on-Trent District Council, Engl.
JOURNAL: R. Soc. Health J. DATE: 1980 VOLUME: 100
NUMBER: 3 PAGES: 86-9, 94 CODEN: RSHEAM ISSN:
0035-9130 LANGUAGE: English

94108174 CA: 94(14)108174q JOURNAL

1009877 ID NO. - E1800209877
ENERGY USE AND SAVINGS IN THE POTTERY INDUSTRY.
 Holmes, W. H.; Cox, R. W.; Davies, E.
 Br Ceramic Res Assoc, Stoke-on-Trent, Engl
 Energy for Ind: a Collect of Sci and Eng Pap Concerned with
 Util Energy with Maximum Effic in Ind Publ by Pergamon Press,
 New York, NY and Oxford, Engl. 1979 p 361-371
 Examples are given of how the British pottery industry has
 already achieved substantial energy savings by using ceramic
 fiber in batch-type firing processes and by recovering waste
 heat from continuous firing processes for drying purposes.
 Three projects recommended to the U. R. Department of
 Industry for funding. All three aim to demonstrate the
 effectiveness of energy-saving equipment by means of
 instrumented surveys and audit work. Ceramic fiber
 insulation, thermal wheels, waste heat boilers and
 recuperative burners are all being assessed as part of this
 work. 2 refs.
 DESCRIPTORS: (+CERAMIC PRODUCTS, +Manufacture), (INDUSTRIAL
 HEATING, Energy Conservation),
 IDENTIFIERS: WASTE HEAT BOILERS
 CARD ALERT: 812, 842, 901

1003385 ID NO. - E1800103385
APPLICATION OF STACK GAS WASTE HEAT RECOVERY.
 Ahrens, Alan C.
 Reynolds Met Co
 Light Met Age v 37 n 7-8 Aug 1979 p 20-21 CODEN: LMAGAL
 ISSN 0024-3345
 A study was initiated to design a preheater which could
 preheat scrap to volatilize organic coatings. It was decided
 that waste exhaust gas from the melting furnace would be used
 as the heat source. The second application involves a rotary
 kiln shot driver. A project was initiated to replace the
 burner with waste flue gas from an adjoining melting furnace.
 DESCRIPTORS: (+FURNACES, MELTING, +Energy Conservation),
 CARD ALERT: 532, 534, 901

1141613 ID NO. - E1810541613
**FIBRE CERAMICHE SEN DASHI UN MEZZO PER RISPARMIARE ENERGIA
 NELL'INDUSTRIA CERAMICA.** sleft brackets Ceramic Fiber as an
 Energy Saver in Ceramic Plants sright brackets .
 Noppen, A. L. D.
 Carborundum Co, Rotterdam, Olanda
 Ceramurgia v 10 n 4 Jul-Aug 1980 p 172-176 CODEN: CRGIAR
 The three commonly used methods of applying ceramic fiber in
 kilns to upgrade their efficiency are described. As well as
 several general applications of ceramic fiber in the ceramic
 industry. In Italian and English.
 DESCRIPTORS: (+KILNS, +Design),
 CARD ALERT: 642

940306 ID NO. - E1790640306
ENERGY CONSERVATION IN THE MANUFACTURE AND USE OF BRICKS.
 West, H. W. H.; Ford, R. W.
 Mellor-Creen Lab
 Proc of the North Am Masonry Conf, Univ of Colo, Boulder,
 Aug 14-16 1978 Sponsored by Masonry Soc, Denver, Colo. 1978
 Pap 102, 17 p
 The conservation of energy has been a major recent concern
 both in the manufacture of bricks and in the use of brickwork.
 Energy audits have been carried out by British Ceramic
 Research Association on selected works and proposals made to
 minimize fuel usage in industry-wide surveys. A new method of
 building has been developed which enables masonry structures
 to be erected more economically and provides for greatly
 increased thermal insulation tailored to particular local or
 statutory requirements.
 DESCRIPTORS: (+BRICKMAKING, +Energy Conservation), (BRICK
 CONSTRUCTION, Energy Conservation),
 CARD ALERT: 414, 812, 405

APPENDIX 2

Visits made by the Industry Task Force

Mr. H. Penn, Brampton Brick Ltd. visited:

Interstate Brick & Ceramic Tile
West Jordan, Utah

Contacts:

Mr. H. Cahoon, V.P. Operations
Mr. V. Ingraham, Plant Manager
Mr. R. Lowrie, R & D Manager

Globe Refractories Inc.
Newell, W. Virginia

Contacts

Mr. S. Porter, Vice President
Mr. R. Moore, Manager Technical Services

Mr. J. Storer-Folt, Canada Brick Ltd. visited:

British Ceramic Research Association
England

Contact

Mr. R. Ford

Lambert Ceramic
Les Mureaux, France

Contact

M. Mansard, Technical Manager

CERIC, Paris France

Contacts

M. C. Comarin, Director of R & D

M. P. Rodriguez, Engineer

C.T.T.B. France

Contact

M. C. Bardin, Chef. des Laboratoire

Mr. J. F. Nicks, Domtar Construction Materials, visited:

Ceramitec

Munich Germany

Contacts

H. D. Boke, Engineer, Karl Walter & Co.

F. Hellmich

H. Jakobides

London Brick Co. Ltd.

England

Contacts

R. Beard, Director of R & D

G. K. Bowler, Chief R & D Officer

The Brick Development Association

England

Contacts

A. J. Monk, Director General

T. L. Knight

J. R. Harding

J. F. Nicks and J. Storer-Folt jointly visited:

C. Keller GmbH Co.

Ibbenbueren-Laggenbeck, Germany

Contact

Dr. W. Kother, Technical Director

"
Institut für Ziegelforschung

Essen, Germany

Contacts

A. Schellback, Manager

N. Pauls

Fraunhofer Institut Für Silicattforschung

Wurzburg, Germany

Contacts

Dr. H. Schmidt, Assistant Director

"
G. Tunker, Mineralogist

POOR

QUALITY

ORIGINAL